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ABSTRACT

Selected materials needed to teach an astronomy unit as well as suggested procedures, activities, ideas, and astronomy fact sheets published by the Manitoba Planetarium are provided. Subjects of the fact sheets include: publications and classroom picture sets available from the National Aeronautics and Space Administration and facts and statistics about the sun, moon, inner planets, outer planets, satellites of the solar system, planetary conjunction of 1981, meteors and meteor showers, comets, the Milky Way, quasars and pulsars, unidentified flying objects (UFO's), and activities of the Manitoba Planetarium. Instructions are provided for making constellation slides and constellation cans, with suggested student activities. Charts of constellations which may be duplicated or used to prepare overhead transparencies are also provided. Additional activities focus on earth rotation/revolution, planets and zodiac, cosmic calendar, survival on the moon, scale diagrams of the solar system, constellation positions, ellipses, planetary orbits, color/temperature relationship of stars, distance measuring devices, and angle measurements. Astronomy books and audio-visual materials available from the Manitoba Education Library and 16-mm films available from the School Film Services are included. (JN)

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MANITOBA PLANETARIUM

Astronomical Information Sheet

NASA EDUCATIONAL PUBLICATIONS

The following is a partial list of Educational publications available from the National Aeronautics and Space Administration, Washington, D.C. These are ideal sources of pictures and resource material for school projects on space and space exploration. The publications should be ordered from:

Superintendent of Documents
U.S. Government Printing Office,
WASHINGTON, D.C. 20402

Payment may be made by cheque or money order payable in U.S. funds. Make sure to include the publication number in your order.

EP-31 SPACE PHYSICS AND ASTRONOMY - A summary of progress in studies of Earth's radiation belts, the magnetic shell around the Earth, the solar wind, the Sun and Earth weather, meteorites, cosmic rays and the role of spacecraft as "robot star gazers". 22 pages/45¢.

EP-54 NASA SPACECRAFT - The present family of NASA spacecraft. All types are discussed, some small, some large; some spin-oriented, some accurately attitude-controlled; some manned, some automated; some free in space until they expire, other commanded to return to Earth or to land on the Moon. 26 pages/50¢.

EP-57 MAN IN SPACE - A chronicle of the Mercury, Gemini and Apollo Manned Space Flight Programs. 30 pages/85¢.

EP-71 "IN THIS DECADE...." - Mission to the Moon - This "pre-launch" booklet outlines the complex steps leading to a manned lunar landing. The many and varied areas of research and development conducted by the National Aeronautics and Space Administration are illustrated. In colour. 48 pages/$1.45.

EP-72 LOG OF APOLLO 11 - The greatest voyage in the history of mankind, the journey of Apollo 11, is documented in this booklet. In colour. 12 pages/35¢.

EP-84 SATELLITES AT WORK - Spacecraft for communications, geodesy and weather observations are described. The new area for working satellites of surveying of Earth resources is also covered. 28 pages/$1.00.

EP-94 APOLLO 15 at Hadley Base - The Lunar Voyage of Endeavour and Falcon is narrated with full colour illustrations and a traverse map. 32 pages/$1.35.

EP-91 APOLLO 14: SCIENCE AT FRA MAURO - Exploration of the upland Fra Mauro area of the moon incorporated the most extensive scientific observations in manned lunar exploration up to that time. The story is presented in text, a traverse map and spectacular colour photographs. 48 pages/$1.25.

EP-06 SPACE SHUTTLE - This publication describes the space shuttle program and augments the material on wall poster. NF-44. /70¢.

EP-97 APOLLO 16 AT DESCARTES - A comprehensive look at the flight of Apollo 16, covering the highlights of the mission, including many detailed colour photographs. /$1.35.

EP-100 APOLLO - Commemorative Book summarizes the historic manned lunar landing program and features in colour some of the best photographs from each Apollo mission. 64 pages/$2.65.

EP-118 OUR PRODIGAL SUN - The dynamic Sun, its characteristics observed and measured by spacecraft, is proving more complex and fascinating than ever; especially for a world anxious to use its store of energy. 14 pages/35¢.

EP-120 QUASARS, PULSARS, BLACK HOLES AND HEAO'S - Astrophysics, the physics of the stars, takes on exciting new dimensions as the result of recent discoveries in the visible high-energy universe where physical processes are so powerful they cannot be reproduced on Earth. 24 pages/80¢.

EP-121 NASA AND ENERGY - NASA is developing ways to tap the heat and light of the Sun to meet the nation's future energy requirements. But that is only part of the story. NASA engineers also are working on clean, renewable fuels; wind-generated electricity; finding new fuel deposits; and exploring a variety of conservation techniques. 16 pages/35¢.

EP-32 LEARNING ABOUT SPACE CAREERS - Provides upper elementary students with ideas and suggestions for things to do to help with a career choice. It includes information about the space industry and the world of work. 24 pages/25¢.

The following are publications in the NASA FACTS Series. They contain condensed information on a NASA Program or a related area of research. Some are in the form of wall posters.

NF-27 LIVING IN SPACE - A description of the life support system devised by science and industry to enable spacecraft crews to remain in space for extended periods of time in an Earth-like environment. 12 pages/30¢.

NF-33 SATURN V - Colour wall poster depicting Saturn V, America's largest rocket vehicle, which launches the Apollo spacecraft. /25¢.

NF-40 JOURNEY TO THE MOON - A colour wall poster depicting manned space flight to the Moon, including landing on the Moon, re-joining the Apollo spacecraft, and the return to Earth. /60¢.

NF-43 SKYLAB - A colour wall poster describing in words and pictures NASA's first earth-orbiting space station - SKYLAB. /60¢.

NF-44 SPACE SHUTTLE - A colour wall poster similar to NF-43, but in this case illustrates NASA's reusable space vehicle, the SPACE SHUTTLE. /60¢.

S-2 SPACECRAFT TRACKING AND COMMUNICATION - Jr. High School - General Science - A Simplified description of the electonics communication bridges between Earth-based controllers and mission-performing manned and unmanned space-craft. /5¢.

S-4 THE COUNTDOWN - Elementary: General Science - Describes the activities and preparations that take place before, during and after the launching of a spacecraft. /5¢.

S-5 WEIGHTLESSNESS - Jr. High School: Physics - Weightlessness is explained by everyday experiences and simple experiments in this description of a complex phenomenon. /5¢.

S-6 SOLAR CELLS - High School: Physical Science - An explanation of the primary source of electrical power for the majority of NASA's unmanned space missions. /5¢.

S-7 ORBITS AND REVOLUTIONS - High School: Physics - A description of the physical and mathematical principles that govern the movement of one body about another in the environment of space. /10¢.

CLASSROOM PICTURE SETS

NASA PICTURE SET #1 - APOLLO - "IN THE BEGINNING...." - Seven 11" x 14" colour lithographs that illustrate highlights from the Apollo 8, 9, and 10 missions. /$1.85 per set.

NASA PICTURE SET #2 - MEN OF APOLLO - Five 11" x 14" colour lithogaphs that include portraits of the crews of Apollo, 7, 8, 9, 10 and 11. /$1.00 per set.

NASA PICTURE SET #5 - MAN ON THE MOON - One 16" x 20" colour lithograph that best illustrates man's moments of success, the first step in his conquest of space. /$1.00 per copy.

NASA PICTURE SET #6 - APOLLO 12 - Pinpoint landing on the Moon. Eight 11" x 14" colour lithographs and two 11" x 14" black and white lithographs illustrating man's return to the Moon. /$2.00 per set.

NASA PICTURE SET #7 - APOLLO 15 - Nine 11" x 14" colour lithographs illustrating the journey to the Moon of Endeavour and Faloon. /$2.10 per set.

MANITOBA PLANETARIUM
Astronomical Information Sheet

"A STAR CALLED SUN"

Our sun is one of a hundred billion stars that make up the giant whirlpool island universe we call the Milky Way Galaxy. It has been in existence for approximately five billion years and may last another five billion. We must consider this brilliant yellow orb in our daytime sky as a tremendous hydrogen bomb, the energy being produced as a result of a fusion process whereby hydrogen, the lightest known element is converted into helium. The sun slowly is evolving into a brighter, hotter star at present, but astronomers are uncertain as to eventual fate: will it continually expand into oblivion? By that time there will surely be no possibility of life on earth, for it will have grown extremely cold--or hot.

SOME FACTS ABOUT THE SUN

Layers	Corona, Chromosphere, Photosphere, core
Mean Distance From Earth	149,600,000 km.
Maximum Distance From Earth	152,083,000 km.
Minimum Distance From Earth	147,260,000 km.
Mass	333,400 Earth masses, or 2.0×10^{27} metric tons
Spectral Type	G2V
Diameter (Photosphere)	109.3 Earth diameters, 139,112 km.
Velocity with respect to the nearby stars	20 km/sec.
Mean Density	1.41 gm/cc
Gravity (at photosphere)	27.9 times that of earth
Visual Magnitude	-26.5
Rotation Period at Equator	24 days, 15 hours
Rotation Period at Poles	Approx. 35 days
Inclination of Pole to Ecliptic	7 degrees 10.5 minutes
Temperature of Photosphere	6000°C
Temperature of Core	14,000,000°C
Average Time Between Minimum and Maximum Numbers of Sunspots	11.1 years (extremes, 7-17 years)
Size of Sunspots	3,000 - 150,000 km; average size approx. 15,000 km.

MANITOBA PLANETARIUM

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STATISTICS OF THE INNER PLANETS

	Mercury	Venus	Earth	Mars
Equatorial Diameter	4,865 km.	12,110 km.	12,756 km.	6,788
Closest Approach to Sun	45,992,200 km.	107,449,700 km.	147,070,400 km.	206,553,600 km.
Farthest Distance from Sun	69,803,500 km.	108,915,500 km.	152,065,900 km.	249,180,500 km.
Period of Revolution	88.0^{d}	224.7^{d}	365.26^{d}	687.0^{d}
Period of Rotation	$58^{d}\ 16^{h}$	243^{d} (Retro)	$23^{h}\ 56^{m}\ 04^{s}$	$24^{h}\ 37^{m}\ 23^{s}$
Length of Day	$175^{d}\ 20^{h}\ 24^{m}$	$117^{d}\ 01^{h}\ 09^{m}$	$24^{h}\ 00^{m}\ 00^{s}$ *	$24^{h}\ 39^{m}$ 25
Inclination of Orbit to Ecliptic Plane	7°	3.4°	0.0° *	1.8°
Inclination of Axis to Plane of Orbit	7° or less	174°	23.4°	24.0°
Mass (Earth = 1)	0.055	0.815	1.000 *	0.107
Density (Water = 1)	5.46	5.23	5.52	3.93
Surface Gravity (Earth = 1)	0.38	0.90	1.00 *	0.38
Composition of Atmosphere	Ionized atomic particles	Carbon dioxide, Ice Crystals	Oxygen, Nitrogen, water vapor	Carbon dioxide, Oxides of nitrogen
Temperature Range at Equator **	290°/700°K.	700° K. (?)	265°/330° K.	200°/290° K.
Albedo (% of Sunlight Reflected by Planet)	5.6%	76%	36%	16%
Synodic Period	116^{d}	584^{d}	—	780^{d}
Number of Satellites	0	0	1	2

*By Definition **T^{o} K. = $(T + 273)^{o}$ C.

MANITOBA MUSEUM OF MAN AND NATURE - PLANETARIUM
Astronomical Information Sheet

THE EARTH - OUR SPACE SHIP

Equatorial Diameter:	12,756 kilometers/7,927 miles
Polar Diameter:	12,714 kilometers/7,900 miles
Amount of Polar Flattening:	1/298.25 or 0.003353
Mass:	5.98×10^{21} metric tons
Mean Density:	5.52 grams/cubic centimeter (Water = 1,000
Surface Gravity:	1.00 by definition (Jupiter = 2.64, Moon = 0.16).
Escape Velocity:	11.2 kilometers/second or 6.94 miles/second
Inclination of Equator to Plane of Orbit around Sun:	23.4 degrees
Mean Distance from Sun	149,600,000 kilometers/92,957,000 miles
Minimum Distance (Perihellon):	147,070,400 kilometers/91,404,800 miles
Maximum Distance (Aphelion):	152,065,900 kilometers/94,509,600 miles
Mean Orbital Velocity:	29.8 kilometers/second or 18.5 miles/second
Velocity of Escape from Solar System at Earth's Distance from Sun:	42.3 kilometers/second or 26.2 miles/second.
Length of Sidereal Day:	$23^h\ 56^m\ 04^s$ of mean solar time, relative to the fixed stars
Length of Solar Day:	$24^h\ 00^m\ 00^s$ by definition. $24^h\ 03^m\ 57^s$ of sidereal time
Length of Sidereal Month:	$27^d\ 07^h\ 43^m\ 12^s$ relative to the fixed stars
Length of Synodic Month:	$29^d\ 12^h\ 44^m\ 03^s$ new moon to new moon
Length of Sidereal Year:	$365^d\ 06^h\ 09^m\ 10^s$ relative to the fixed stars.
Length of Tropical Year:	$365^d\ 05^h\ 48^m\ 46^s$ vernal equinox to vernal equinox
Temperature Range at Equator:	265/330 degrees Kelvin or +20/+135 degrees Fahrenheit
Albedo (% of Reflected Sunlight):	36%
Composition of Atmosphere:	Oxygen, Nitrogen, Water vapor
Earth's Motion as a Member of the Solar System:	
1. Sun's Local Motion - Direction:	Toward the constellation Hercules
- Velocity:	19.4 kilometers/second or 12.1 miles/second
2. Sun's Revolution in our Galaxy:	
Distance to Centre:	30,000 light years/10,000 parsecs
Period of Revolution:	2.2 million years
Orbital Velocity:	260 kilometers/second or 160 miles/second

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THE MOON - OUR NEAREST NEIGHBOUR IN SPACE

In 1969, the moon became the first astronomical body to be visited by man. Many theories about the origin and nature of the moon were put to rest as a result of this and of subsequent visits through the end of 1972. The lunar rock samples and the data sent back by instruments deployed on the moon by the astronauts will continue to provide, for decades to come, information of the nature of the moon and on the origin of the solar system.

Mean Distance from Earth:	384,344 Kilometers/238,865 miles
Minimum Distance (Perigee):	356,334 Kilometers/221,463 miles
Maximum Distance (Apogee):	406,625 Kilometers/252,719 miles
Sidereal Period of Revolution:	$27^{d}\ 07^{h}\ 43^{m}\ 12^{s}$ relative to the fixed stars.
Synodic Period of Revolution:	$29^{d}\ 12^{h}\ 44^{m}\ 03^{s}$ new moon to new moon
Periods of Rotation:	Same as periods of revolution
Stellar Magnitude:	-12.7 at full moon (This is 40,000 times the brightness of a first-magnitude star).
Equatorial Diameter:	0.273 earth diameters/3,476 km./2,160 ml.
Degree of Polar Flattening:	Nil
Mass:	0.0123 earth masses/6.57×10^{19} metric tons
Averace Density:	3.36 grams/cubic centimeter (water = 1,000)
Surface Gravity:	0.165 earth gravity (eg. 150 lb. weighs 25 lb)
Escape Velocity:	2.2 kilometers/second or 1.5 miles/sec.
Atmospheric Composition:	Nil
Temperature - Sunlit Side:	382° Kelvin/+230° Fahrenheit*
Temperature - Dark Side:	94° Kelvin/-289° Fahrenheit*
Albedo (1% of reflected sunlight):	8.6%
Inclination of Equator to Orbit:	6.7 degrees
Inclination of Equator to Plane of Solar System:	Variable: 18 to 29 degrees
Inclination of Orbit to Plane of Solar System:	5.15 degrees
Eccentricity of Orbit:	0.0549

*T^{o} Kelvin = $(T - 273)^{0}$ Celsius

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STATISTICS OF THE OUTER PLANETS

	Jupiter	Saturn	Uranus	Neptune	Pluto
Equatorial Diameter	142,749+	120,862+	46,993+	44,579+	5,600-12,900+
Closet Approach to Sun	740,670,224+	542,925,926+	2,734,690,313+	4,458,083,758+	4,423,742,739+
Furthest Distance from Sun	816,068,698+	1,506,473,283+	3,005,466,545+	4,535,875,842+	7,376,680,569+
Period of Rotation	$9^h50^m30^s$	10^h14^m	10^h49^m (Retro)	14 hours	$6^{dgh}16^m$
Length of Day	"	"	From 10^h49^m to 42 years	"	"
Period of Revolution	11.86 yrs.	29.46 yrs.	84.01 yrs.	164.8 yrs.	247.7 yrs.
Inclination of Orbit	1.3°	2.5°	0.8°	1.8°	17.2°
No. of Satellites	13 or 14	10	5	2	1
Mass (Earth=1)	318.0	95.2	14.6	17.3	0.05
Density (Water=1)	1.33	0.69	1.56	2.27	4
Surface Gravity (Earth=1)	2.64	1.13	1.07	1.41	0.3
Composition of Atmosphere	Hydrogen Helium Neon Methane and Ammonia	Hydrogen Helium Neon Methane and Ammonia	Hydrogen Helium Methane	Hydrogen Helium Methane	Undetectable
Temperature Range at Equator	-157°	-171°C	-184°C	-198°C	-212°C
Albedo (% of sunlight reflected)	73%	76%	93%	84%	14%
Synodic Period	399^d	378^d	370^d	367^d	367^d
Inclination of Axis	3°	27°	98°	29 1/2°	?

Distances in Kilometers +

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SATELLITES OF THE SOLAR SYSTEM

Designation		Diameter km	Distance from Planet km	Period d h m	Discovery
Earth 1	Moon	3,476	384,000	27 07 43	--------
Mars 1	Phobos	23*	9,000	00 07 39	1877, Hall
Mars 2	Deimos	13*	23,000	01 06 18	1877, Hall
Jupiter 5	Amalthea	(160)	180,000	00 11 57	1892, Barnard
Jupiter 1	Io	3,660*	422,000	01 18 28	1610, Galileo
Jupiter 2	Europa	2,880	671,000	03 13 14	1610, Galileo
Jupiter 3	Ganymede	5,460*	1,070,000	07 03 43	1610, Galileo
Jupiter 4	Callisto	4,460	1,884,000	16 16 32	1610, Galileo
Jupiter 13	Leda	(5)*	10,200,000*	210 15 --*	1974, Kowal
Jupiter 6	Himalia	(100)	11,477,000	250 14 --	1904, Perrine
Jupiter 7	Elara	(40)	11,738,000	259 16 --	1905, Perrine
Jupiter 10	Lysithea	(15)	11,857,000	263 13 --	1938, Nicholson
Jupiter 12	Ananke	(15)	21,240,000	631 02 --R	1951, Nicholson
Jupiter 11	Carme	(15)	22,530,000	692 12 --R	1938, Nicholson
Jupiter 8	Pasiphae	(15)	23,500,000	738 22 --R	1908, Melotte
Jupiter 9	Sinope	(15)	23,700,000	758 -- --R	1914, Nicholson
Saturn 10	Janus	(350)	160,000	00 17 59	1966, Dollfus
Saturn 7	Mimas	(900)	187,000	00 22 37	1789, Herschel
Saturn 8	Enceladus	550	238,000	01 08 53	1789, Herschel
Saturn 5	Tethys	1,200	295,000	01 21 18	1684, Cassini
Saturn 6	Dione	800	378,000	02 17 41	1684, Cassini
Saturn 4	Rhea	1,300	526,000	04 12 25	1672, Cassini
Saturn 1	Titan	5,800*	1,221,000	15 22 41	1655, Huychens
Saturn 2	Hyperion	(320)	1,480,000	21 06 38	1848, Bond
Saturn 3	Iapetus	(1,150)	3,561,000	79 07 56	1671, Cassini
Saturn 9	Phoebe	(260)	12,960,000	550 11 --R	1898, Pickering
Uranus 5	Miranda	(550)	124,000	01 09 56	1948, Kuiper
Uranus 3	Ariel	(1,450)	191,000	02 12 29	1851, Lassell
Uranus 4	Umbriel	(970)	267,000	04 03 38	1851, Lassell
Uranus 1	Titania	(1,800)	438,000	08 16 56	1787, Herschel
Uranus 2	Oberon	(1,600)	587,000	13 11 07	1787, Herschel
Neptune 1	Triton	3,800	354,000	05 21 03R	1846, Lassell
Neptune 2	Nereid	(530)	5,570,000	359 10 --	1949, Kuiper
Pluto 1	1978 P1	Provisional Designation	20,000	06 09 17	1978, Christy

MERCURY and VENUS have no known satellites.

*-Recent Value ()=Uncertain Value R=Retrograde Orbit

Io, Europa, Ganymede and Callisto were discovered by Galileo with a crude telescope, and they can be seen in an ordinary pair of 6 or 7 power binoculars.

Charles Kowal at Cal. Tech. has detected an object that may be a 14th moon of Jupiter.

THE GREAT PLANETARY CONJUNCTION OF 1981

The Great conjunction of 1981 is unusual because Jupiter and Saturn appear to pass each other three times this year, between January and the end of July. The earth must be in exactly the right position in space for us to see a triple Jupiter/Saturn approach. The event is a rare one. The last similar triple conjunction occured in 1940-41, and the next will not happen for 258 years.

As the planets orbit the Sun, from our viewpoint on Earth, they occasionally appear to move very close together. When they appear closest together they are said to be in conjunction. Of course, the planets never really get close in space. At present Jupiter is 700 million kilometers from Earth. Saturn is in the same direction as Jupiter, as seen from the Earth, but it is nearly twice as far away at a distance of 1.3 billion kilometers.

As Jupiter and Saturn move around the sky, Jupiter overtakes Saturn and the planets come into conjunction about every 19 years. The planets seldom come so close together that they appear as one star. Usually they pass within a degree or two of each other. For reference, the Moon appears 1/2 degree in diameter.

This is the last conjunction of Jupiter and Saturn that will be visible until December 21, 2020. The conjunction of May 28, 2000, will be so close to the Sun that it will be invisible in the Sun's glare. The 1981 triple conjunction is the eleventh since 7 BC. The 7 BC conjunction, according to some scholars, set the Wise Men on their journey to Bethlehem, and provided the origin for the Planetarium's story of the Christmas Star.

The following is a timetable of events to watch for in 1981:

Wednesday, January 14	First Conjunction - Jupiter and Saturn 1.1 degrees apart. (The Moon is 1/2 degree across).
Sunday, January 25	Moon within 2 or 3 degrees of Jupiter and Saturn. This will be a very pretty sight between 11 p.m. and dawn.
Thursday, February 19	Second Conjunction. Jupiter and Saturn, after moving apart slightly are again close, only 1.1 degrees apart.
Saturday, February 21	Moon again close to Jupiter and Saturn.

THE GREAT PLANETARY CONJUNCTION OF 1981 cont'd.

Thursday, July 30	Third Conjunction. Jupiter 1.2 degrees from Saturn. In the winter and spring these planets were seen in the late night and morning sky. Now they are in the southwest early in the evening.
July 25 to July 28	Venus moves past Jupiter and Saturn coming within 2 degrees of Jupiter and 0.9 degrees of Saturn. These three planets will, by the end of July be very low in the southwest at sunset.

Between the first and second conjunctions, the separation between the planets increases only from 1.1 degrees to about 1 1/4 degrees. Since Jupiter and Saturn are moving near a faint star, Eta, in the constellation Virgo, it is easy to note even the minute day to day changes in their positions.

Between the second and third conjunctions the planets will separate until they are nearly 3 degrees apart in mid-May. Between August 24 and Sept. 1, Jupiter, Saturn, Venus, the Moon and the bright star Spica will form a series of configurations in the southwestern sky in the evening. These will be fascinating to watch as they change their positions day to day.

A pair of binoculars, if focused carefully and braced against a fence post or a door frame will give an interesting view of the Moon and Planets. (Do not look through a window as it will make the image fuzzy). Binoculars won't quite show the rings of Saturn, but they will show the craters on the Moon and four of Jupiter's Moons.

for further information:
Bill Peters or
Kathy Roos Pavlik
956-2830 ext. 127 or 147

MANITOBA PLANETARIUM

Astronomical Information

METEORS AND METEOR SHOWERS

The earth is constantly bombarded by large and small particles from outer space. Since the earth travels through space at a velocity of almost 108,000 kilometers per hour, it often collides with particles in space which are heated up as they enter the atmosphere. Most of the smaller pieces burn up before they reach the ground. Some of the larger ones that do reach the ground are recovered. These are called meteorites. Meteorites fall into three classes; stony (aerolites), irons (siderites) and stony-irons (siderolites). Stony meteors often break up at the end of their flight. Meteors whose trains are coloured are likely to be metallic in composition.

DEFINITIONS: The particle, when it is still in space, is called a meteroid; the luminous phenomen caused when the particle enters the earth's atmosphere is a meteor; and if it survives and lands on the ground, the particle is a meteorite. No known meteorite is of shoer origin.

SOME FACTS ABOUT METEORS

Velocity of Observed Meteors	144,000 km./hr	15-75 km/sec.
Average Rate of Visible meteors for a single observer (not during shower)	10 per hour	
Rate of a Shower	15 - 50 per hour	
Daily Mass of Material Reaching Earth	50 - 100 Metric Tons	
Meteor Surface Temperature at Maximum	300°K	
Height of Appearance of Meteors	Sporadic 100 km.	Shower 115 km.
Largest known Meteorite	9 cubic meters (found in South Africa)	

MANITOBA PLANETARIUM

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COMETS

Comets are strange space wanderers, once regarded as from outer space, but now regarded as being part of our solar system, some of the stuff left over when the planets formed. This leftover material orbits the sun outside Pluto, and occasionally some condensations of it form and begin to travel in altered paths that bring them within our observation. As they approach the sun they begin to glow as the frozen material of the comet is turned to gas and excited by the sun's radiation.

Four names are given to observable parts of a comet. The head is called the coma and may show two characteristics; an indistinct central condensation and a much smaller bright fuzzy spot called the nucleus. Extending away from the coma is the characteristic tail of the comet. The tail is formed by gases and small particles driven out of the coma by the solar wind and radiation pressure of the sun. The tail may fork, the lighter gas molecules being driven in straight lines away from the sun by radiation, and heavier dust particles curving away affected both by solar wind and gravitation.

Periodic comets are those known to reappear at more or less regular intervals. All comets are now regarded as probably periodic unless perturbed so that they escape from the solar system.

SOME FACTS ABOUT COMETS

Average period of a periodic comet	Approx. 7 years (most of the bright ones are longer than this)
Average perihelion distance (closest approach to the sun)	153,000,000 km.
*Average magnitude	9.5
Rate of Discovery of Comets	
New Indefinite Period	3 per year
New Periodic	1 per year
Periodic (predicted and observed on a subsequent passage)	2.5 per year
Comets visible to the naked eye	2 per year
Average number of appearances before breaking up	7
*Diameter of coma	Approx. 274,000 km.
Diameter of central condensation	Approx. 2,700 km.
Diameter of nucleus	Approx. 13 km.
Length of tail visible to the eye	from 9,650,000 km. to 200,000,000 km. in special cases

Solar distance at which tail appears	Approx. 240,000,000 km.
Atoms & molecules observed in comet heads	Water, Sodium, Carbon, Cyanide, Methane, Ammonia
Atoms & molecules observed in comet tails	Cyanide, Nitrogen, Carbon Dioxide

*These characteristics change with solar distance and thus are given here for the perihelion distance.

MANITOBA PLANETARIUM

Astronomical Information Sheet

THE MILKY WAY

Our sun is located approximately two thirds of the way out from the centre of a huge aggregation of stars that is shaped like an enormous pinwheel. The pinwheel is slightly thicker at the centre than at its edge, and is called the Milky Way Galaxy. Distances in our Galaxy are so great that it is impractical to use our familiar yardsticks such as centimeter, meters and kilometers to measure them. The measurement that astronomers often use is called the light-year, and it is the distance that light can travel (at 300,000 km. per second) in the course of one year. However, for reasons of convenience, astronomers more often use the parsec to measure distances. The parsec is equal to 3.26 light years, and thus contains about 30,850,000,000,000 kilometers!

Astronomers find that our sun and the rest of the stars in the galaxy are moving with respect to each other as our galaxy rotates. Although this movement is quite rapid, the distances involved are so great that we could not notice the change in position of any of the stars until tens of thousands of years had passed!

We also know that the galaxy contains, besides individual stars, gas clouds (called nebulae) and special groups of stars called clusters. These are all rotating around the centre of the galaxy with all the rest of the stars.

SOME FACTS ABOUT THE GALAXY

Diameter	25,000 parsecs (pc.)
Thickness at the centre	4,000 pc.
Thickness at the sun's location	300 pc.
Distance between spiral arms	1,400 pc.
Thickness of spiral arms	600 pc.
Mass	1.1×10^{11} solar masses
Period of Rotation of the Sun around the Galaxy	200,000,000 years
Velocity of the sun's motion in the Galaxy	774,000 km. per hour

MANITOBA PLANETARIUM
Astronomical Information Sheet
QUASARS AND PULSARS

Quasars are possibly the most puzzling astronomical objects yet discovered. Although we have known about them since 1960, astronomers have not yet been able to explain them. They were first noted as being very small sources of powerful radio waves. Optical telescopes revealed them as objects that looked like stars. However, our spectroscopes show us that they are travelling away from us with enormous velocity, greater than that of any object in space that we have observed so far.

Astronomers believe that the very high velocity of quasars is due to the expansion of the universe. This would mean that they are the most distant objects ever observed, with distances up to 9 billion light years! However, they seem much too bright to be so far away. If they really were at that distance they would have to be as bright as one hundred thousand million of our suns! Astronomers are still not sure if it is even possible for an object to be that bright!

We also find that the light from these objects is variable. The laws of physics tell us that an object which varies as rapidly as quasars do, must be quite small. However, if they are as bright as mentioned above they certainly cannot be that small.

Unfortunately, we find that as our observations of these objects increase, we find no answers, only more questions. Some astronomers believe that quasars are early stages in the formation of a galaxy. Others feel that they might not even be all that far away, but then it is difficult to explain the high velocity.

It is very likely that the puzzle of the quasars will remain unsolved for quite a number of years.

Pulsars, on the other hand, were very quickly explained after being discovered. The first one was observed in 1967 by astronomers at Cambridge University using a radio telescope. They found that the pulsar emitted radio pulses about once every second. The remarkable feature of these pulses was their regularity. They would repeat with an accuracy of much less than one one-millionth of a second. For a short time it was believed that they might be signals from some intelligent civilization on another world. However, soon many more were discovered and this theory was discounted.

It was not long before pulsars were identified with faint stars that appeared to be quite unusual in nature. These were believed to be neutron stars; the final product of the cataclysmic explosion of a very old star. This explosion is called a supernova. The neutron star theory was proven to be correct when a pulsar was discovered in the Crab Nebula, the known remains of such an explosion.

These neutron stars are rotating extremely rapidly and have strong magnetic fields. The combination of these two characteristics gives rise to the rapid radio pulses.

Although astronomers have now solved the mystery of pulsars, they are still very much interested in them. They can tell us a great deal about the life cycle of stars, and their radio pulses can be used to perform other experiments in space to test theories like relativity, for example, or to study the nature of invisible material in outer space.

RESOURCES LIST

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ROGER WOLOSHYN (EDUCATION) ext. 125
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- UNIVERSE
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- APOLLO 17: ON THE SHOULDERS OF GIANTS

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MANITOBA PLANETARIUM

Astronomical Information Sheet

The Manitoba Planetarium is a multi-purpose audio visual theatre dedicated to providing the best in Astronomical and Entertainment programming for Manitobans and visitors. The Planetarium project was inspired by Canada's Centennial in 1967 and its construction was, in part, made possible through the generosity of the family of Saidye and Samuel Bronfman. Since the Manitoba Planetarium opened on May 15th, 1968 it has attained a significant place in the international Planetarium community. In addition, it has hosted light shows, religious services and artistic performances.

THE STAR THEATRE

The Planetarium's dome is the biggest projection screen in Manitoba. Literally hundreds of projectors work together to fill it with imagery. One hundred and fifty four separate projectors are clustered on the Zeiss Planetarium Projector in the centre of the room. These projectors work together to show nearly 9,000 stars - all that the unaided eye can see - as well as the Sun, Moon and Planets. The Zeiss Instrument gears these projectors together so accurately that they can be used to show the sky as our ancestors saw it thousands of years ago, or as Earthlings will see it far in the future.

When the Carl Zeiss Optical Company of Oberkochen, West Germany produced this projector in 1966 it sold for $200,000. The current cost of a similar projector is in excess of $1 million.

The Planetarium Design and Engineering staff has created the many special effects projectors that are hidden in the projection gallery, running all around the bottom edge of the dome. These projectors can produce an awe inspiring sunset, the landscape on distant world, the strange views seen by an interstellar traveller, or even a death defying plunge through a Black Hole. All of the projectors are run by a very busy operator from the control console in the Star Theatre.

PLANETARIUM SHOWS

Most Astronomical shows are written and produced right at the Manitoba Planetarium. Occasionally an outstanding production, created at another Planetarium, is presented in the star theatre. Scripting, artwork, and recording are done by the Planetarium's Director, Producers and Artist/Photographer. Narrators, actors, actresses and film-makers of local and national stature add their talents to the creation of the feature presentations.

Over a dozen exciting programs are presented every year for students from kindergarten through high school. These shows touch all aspects of astronomy, from the intriguing sky lore of the ancient Greeks to the mysterious Quasars at the edge of the visible Universe.

PLANETARIUM INFORMATION

To see a feature presentation call 943-3142 for show times and information. Information and bookings for our complete range of School Programs is available at 943-3204. Group visits and special events can be arranged by calling the Planetarium offices at 956-2830. When planning a visit be sure to leave time to tour the Hall of Astronomy, a 7,500 sq. foot exhibit gallery that takes a colourful look at star-gazing from ancient times through the revelations modern telescopes and spaceflight. In the gallery the Copernicus Solar Telescope projects an impressive, detailed, 52 inch diameter image of the Sun, every clear day.

THE SKY SHOW

For a brief, fun course in skywatching to really start appreciating the wonders of a dark evening sky, don't miss "The Sky Show". This special performance is presented live on the second Sunday of each month at 5:00 pm. and it includes a free star map.

MANITOBA PLANETARIUM
and
MANITOBA CENTRE FOR U.F.O. STUDIES

UNIDENTIFIED FLYING OBJECTS

I. What is a U.F.O.?

An Unidentified Flying Object is exactly what it's name implies. It is something that seems to travel through the air or even to land, but we cannot explain what it is.

More than 90% of all the Unidentified Flying Objects that are reported, can ultimately be identified as natural or man made phenomena. However, even after careful analysis by skeptical investigators, a small number of reported sightings remain completely mysterious. Such a wide variety of observations fit in this unexplained category that one prominant investigator, Dr. J. Allen Hynek has sorted them into three main groups for convenience:

1. Close Encounters of the First Kind: In which the reported UFO is seen at close range but there is no interaction with the environment.

2. Close Encounters of the Second Kind: Are those where physical effects on both animate and inanimate material are noted, i.e., vegetation has been pressed down, burned or scorched, tree branches broken, animals frightened. Vehicles have become momentarily disabled. After the close encounter of the second kind left, the vehicles were usually able to operate again.

3. Close Encounters of the Third Kind: In which the presence of "Occupants" are reported in or about the UFO. There should be a distinction made between this type of report and the so-called contactee cases. The latter are characterised by a "favoured" human intermediary who believes he/she has been "chosen" by the space people as their regular contact to spread the messages they give to the contactee. These messages usually deal with such things as "be good, stop fighting, stop polluting the atmosphere and ban the bomb" etc. This later type of reporting is not classified as close encounters of the third kind.

Reference: Dr. J. Allen Hynek - "The UFO Experience" pgs. 28-31 inclusive.

In addition to the close encounter catagories there are two broad groups.

Nocturnal Lights: Unidentified lights, seen at night, which usually only the relative brightness, color and motion are reported.

Daylight Disks: Unidentified objects, usually oval or disk-shaped seen during the day.

What do these close encounters and unexplained sightings mean?

There simply isn't enough conclusive evidence to give a good answer to that question but many people have theories or beliefs about what the answer should be.

II. The Problem of Objectivity?

Scientists usually attack an unexplained phenomena by thinking up a hypothesis that seems to explain what is going on. Then they do some experiments or make some observations which are critical tests of the hypothesis to determine whether it is true or false.

Very often in science, until the correct theory comes along or until a good set of tests are invented, several hypotheses will exist side by side to explain some phenomena. This is exactly what seems to be happening in the case of Unidentified Flying Objects. There are several hypotheses but so far the process of supplying critical tests hasn't really begun.

Unfortunately, some "investigators" of unidentified flying objects have already made up their minds about the phenomena. Rather than seeking the critical tests for their theory, they pick out bits and pieces of evidence that seem to prop up their ideas and they use these bits and pieces to sell their beliefs in sensational articles and books. Some of these "investigator's" tales might make gripping or even scary reading, but they do little to solve the problems of what U.F.O.'s are. We recommend that all books and articles be read with a very critical mind. The mere fact that a statement or even a picture exists on a printed page does not guarantee that it is true. A good author will always state the sources of his information. But even if this seems to be done you still have to ask "do his sources seem to be reliable?" "Am I hearing all sides of the story or only the facts that fit this theory?" Uncritical beliefs may ease the mind by erasing the doubts and questions but they do absolutely nothing to increase our knowledge about U.F.O.'s.

III. The Evidence Problem

In August 1972 a meteor so bright that it could be seen in full daylight, went streaking across the skys of North America. It appeared suddenly, was visible for scant minutes, and then disappeared. Yet the eye witness reports of this phenomena and the photographs by amateur photographers were so complete that Astronomers who studied the reports could learn almost everything they wanted to know about the object.

Astronomer and exobiologist Carl Sagan has pointed out that U.F.O.s are seen frequently by large groups of people, yet none have been as well photographed and as well reported as this single rare meteor was. Why not? There's no easy answer to that question.

Psychological suggestion deserves more study than it has received thus far. Any stage hypnotist can easily demonstrate the power that an authoritarian figure exercises over a susceptible subject, even to the extent of altering the subjects perception. It could be that pre-conceived or even subconscious notions of what U.F.O.'s are, effects our reports. Even ignoring the less obvious psychological problems, there's another problem with U.F.O. evidence.

Since the photographs are poor, most of the evidence consists of eye witness reports. Unfortunately, eye witness reports tend to be highly unreliable. And this is true of eye witness reports of just about everything, not only U.F.O.'s. A law professor once demonstrated this to his class by arranging a "crime" to take place in front of them. When the class convened, one of the students got up, "shot" the professor with a blank cartridge and fled from the room. After allowing the confusion to continue for a minute or two the professor revealed that he was unhurt. That day's assignment was to write an exact account of what each student had seen. At the end of class the professor collected as many different accounts of the event as there were students in the room, and the differences weren't minor either. In the confusion, some of the observers had even managed to switch, in their minds, the victim and the assailant.

IV. Recording and Reporting a U.F.O.

If you see a U.F.O. it is important to get as many other witnesses as possible. If you have a camera handy be sure to take lots and lots of pictures. Along with your observation of the object, U.F.O. investigators will want to know the date, the time, the weather conditions, the shape of the object, its color, its behaviour and motion, and its size compared to the size of objects that you can see around you while observing it, and its apparent speed. They will also be interested in the duration of the appearance and how the object disappeared.

If there are a number of witnesses record their names, addresses and telephone numbers. As soon as you can, try and make a drawing of the object to keep the event fresh in your mind. Once you are satisfield that the U.F.O. is really unidentified and not just an unusual look at something familiar like an airplane, the planet Venus, a weather balloon, a flight of birds over the city illuminated by street lights at night, then call the Manitoba Planetarium at 190 Rupert Avenue, Winnipeg, Manitoba, Canada, R3B ON2, area code 204-956-2830 during business hours and ask to talk to a representative of the Manitoba Centre for U.F.O. Studies. Reports are accepted in confidence and no details relating personally to the witnesses or associated parties will be made public, without written authorization from the individuals concerned. Remember, to be of use, reports must be complete. All of the information listed above is needed to make further study possible.

Over 90% of the things that people report as U.F.O.'s can be explained. This is partly due to the fact that many are simply unfamiliar with the ways the moon and planets and other celestial objects appear overhead. A visit to the planetarium to enjoy the wonders and the splendors of the sky will help to make you a better observer of U.F.O.'s.

V. Extraterrestrial Life

The most persuasive explanation for U.F.O.'s is that they are piloted or controlled by intelligences who inhabit some other place in the Universe besides the planet Earth. Present scientific knowledge does not exclude this possibility. Terrance Dickinson, reporting to the 1977 General Assembly of the Royal Astronomical Society of Canada has concluded that in our galaxy, The Milky Way, there are possibly four hundred earth like civilizations. That's an optimistic estimate, he also concludes that it's distinctly possible that we are alone. Dickinson's arguments are entirely statistical ones. The planets in our own solar system are the only planets that we have solid evidence for. Scientists have indirect evidence that there are planets about many other stars, but even the largest telescopes won't give us a look at any of these.

When we contemplate the idea of travelling to other stars, the problems seem very great. Travelling as close as we could to that Universal speed limit, the speed of light, it would take many years to reach even the nearest star, Alpha Centauri which is 4 1/3 light years away. Science Fiction writers have invented hyper-drives to the speed of light but these ideas remain science fiction. It may or may not be possible to exceed this cosmic speed limit. At the moment we simply don't know.

One thing is certain. If U.F.O.'s are space ships from elsewhere those controlling them have found ways to do things we find exceedingly difficult. This may be the case. However, its equally likely that some day those who believe that U.F.O.'s are interstellar visitors will be disappointed when it's established that U.F.O.'s are actually something far different, perhaps even something psychological rather than something physical.

Further reading:

HYNEK, Allen J.

The UFO Experience

The Hynek UFO Report

The Edge of Reality

VALLEE, Jacque

Challenge to Science, The UFO Enigma

Pass-Port to Magonia

Invisible College

FULLER, John G.

Incident At Exeter

Interrupted Journey

JACOBS, David Michael

The UFO Controversy in America

LORENSEN, Coral & Jim

Encounters with UFO Occupants plus many other good UFO books

There are hundreds of UFO and related books on the market. The above authors represent the best of these.

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February 1981

ASTRONOMY

The following bibliography represents the holdings of the Department of Education Library in the area of "Astronomy". These materials may be obtained by submitting a request by mail, in person, or by telephoning the Library.

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E 523.1 As — Asimov, Isaac. Galaxies. Chicago: Follett, 1968.

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523 Jo — Johnson, Gaylord. Story of planets, space and stars. New York, Harvey House, 1959.

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B. AUDIO-VISUAL MATERIAL

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1 tape cassette, 30 min.

VR 523.38 E24 — Eclipse '79. (Videorecord) University of Winnipeg, 1978.
1 tape cassette, 38 min. color 3/4".

VR 523.38 E24 r — Eclipse '79. (Videorecord) University of Winnipeg, 1978.
1 tape, 28 min. color 1/2".

VR 523.38 E25 — Eclipses. (Videorecord) University of Winnipeg, 1978.
1 tape cassette, 24 min. color 3/4".

VR 523.38 E25 r — Eclipses. (Videorecord) University of Winnipeg, 1978.
1 tape, 24 min. color 1/2".

K 523 I57 — National Geographic Society. An introduction to the amazing universe. Washington, National Geographic Society, 1978.
2 filmstrips, 2 sound cassettes, 2 guides.

K 372.4 L41 m — National Geographic Society. The moon. Washington, D.C., National Geographic Society, c1978.
1 filmstrip, 1 cassette, 3 study prints, 10 masters (Learning shelf kit).

K 523.2 N48 — The new solar system. Stamford, Conn., Educational Dimensions, 1976.
2 filmstrips, 2 audiotapes, 1 teacher's guide.

B. Audio-Visual Material (Con't)

K
910
097

Our planet the earth. New York, Filmstrip House, c1966.
6 filmstrips, 2 sound discs, 1 discussion guide.

K
523.207
S64

The solar system. Carson, Calif., Educational Insights, c1975.
52 cards, 1 index box.

VR
520
S63

Space study. Manitoba School Broadcasts and CBC, 1975.
3 tape cassettes, 30 min. each color.

K
520
S79

Studies in science set 2. Glendale, Calif., Walt Disney Educational Materials, c1968.
7 filmstrips, 7 audiotapes, 7 filmstrip study guides.

K
523.89
V53

The view from spaceship earth. La Verne, Calif., David Chandler, c1978.
1 chart, 1 viewer.

16 MM FILMS FROM SCHOOL FILM SERVICES

ABOUT ASTRONAUTS (11 min., color). Film footage from the Apollo lunar flights provides the visual base for the answers to the questions of a child's letter to NASA: Is being an astronaut really dangerous? The moon is not as big as the earth -- doesn't that mean people weigh less up there? How long is it before you come back to earth? Is moonwalking really that different from earthwalking? It takes a lot of people to launch a spaceship -- are all those people necessary? Is it true that scientists can learn more about the earth and the whole universe by studying the moon?
(1973) Primary to Jr. High.

AMAZING ADVENTURES OF GEMINI IV (10 min., b & w). (1965) Primary to Sr. High.

COMETS, METEORITES AND ASTEROIDS (11 min., color). Comets, Meteorites and Asteroids are called the minor members of the solar system. This film shows: 1) how astronomers have learned about these objects travelling around the sun; 2) what each group looks like; and 3) the place of each in the solar system. The film illustrates the newest objects in the solar system: Man-made or artificial, satellites.
(1962) Jr. High to Sr. High.

CONTROVERSY OVER THE MOON (16 min., color). The film presents the "controversy" concerning the geological make-up of the moon -- specifically the origin of large lunar craters. Two eminent scientists interpret available data and discuss reasons for their divergent views.
(1971) Intermediate to Sr. High.

EARTH, SUN, MOON & STARS - POSITION OF THE MOON (8 min., color). Actual pictures of the moon as well as space planetarium views show the moon as earth's nearest neighbour in space, explaining fully the major movements of the moon, its revolving and rotating, and the causes of moonlight. Demonstrations show the comparative sizes of the earth, sun and moon, and their relative distance from one another.
(1971) Intermediate to Jr. High.

ECLIPSE AT GRAND'MERE (10 min., b & w). The eclipse of the sun on July 10, 1963, drew scientists and amateur stargazers from far afield to the little out-of-the-way town of Grand'Mere, Quebec, a place where the total eclipse was to be plainly visible. This film presents candid camera views of the festivities with which the modest town greeted the influx of visitors, and also shows the once-in-a-lifetime spectacle of the moon inching across the face of the sun, to blot it out completely.
(1965) Jr. High to Sr. High.

ECLIPSES OF THE SUN AND MOON (11 min.). Stop-motion and time-lapse photography are used to bring an actual solar eclipse to the screen. An animation sequence reveals the cause and effect of a total solar eclipse.
(1966) Jr. High to Sr. High - Adult.

EDGE OF THE UNIVERSE, TO THE (22 min., color). An account of the construction, in Algonquin Park, Ontario, of a radiotelescope designed by Canada's National Research Council, and how it was used to measure, working simultaneously with the telescope of the Dominion Radio Astrophysical Observatory at Penticton, B.C., the first arc of a "quasar" (quasi-stellar radio source) at the outermost fringe of our universe. The success of this probe opened up new possibilities of astronomical enquiry.
(1973) Sr. High.

EXPLORING THE MOON (20 min., color). (1960) Intermediate to Sr. High.

FIRST MEN INTO SPACE (20 min., color). Solving the space survival problems. Recreates, with live photography, film animation, and scale models, the first American orbital space flight, and illustrates some of the problems of man's survival in this hostile environment. Shows how such problems as decreased air pressure, multi-weight, and weightlessness were studied and how solutions were applied by engineers to the first space capsule project.
(1962) Intermediate to Sr. High.

HOW WE EXPLORE SPACE (16 min., color). An introduction to the instruments astronomers use and the methods used to explore space and to study planets and stars. The instruments shown are the telescope, camera, spectroscope and photo-cell. The various planets are examined by these instruments. Also, included, are some of the first color pictures taken of Mars.
(1958) Jr. High to Sr. High.

HOW WE KNOW THE EARTH'S SHAPE (11 min., color). We use a globe as a model to represent the shape of the earth. But how do we know what the earth's shape really is? The film shows how, during the centuries, man has changed his ideas about what the earth looks like: from flat, to curved, to round, to flattened and bulging, to pear-shaped. Yet, a perfectly round globe is still the best model of the shape of the earth.
(1960) Elementary to Jr. High.

MILKY WAY AND BEYOND (20 min., color). Presents the relationship of our solar system to the galaxy of which it is a part. Telescopic color photography and effective animation illustrate what stars are and how they are formed. An expanding picture of the universe is gained as other galaxies and their movements are portrayed.
(1961) Intermediate to Sr. High.

MOON, THE (15 min., color). (1963) Primary to Intermediate.

OTHER PLANETS - NO PLACE LIKE EARTH (30 min., color). What are the similarities and differences between Earth and the other planets of the solar system? Computer animation is used to summarize the knowledge scientists have gained to date.
(1971) Intermediate to Sr. High.

RED PLANET, MARS (17 min., color). Animation and still photographs are used to show Mars in the solar system. Historical observations are cited. With diagrams for the space satellites, indication is given of how man may one day be able to get a closer view of the surface of the planet. Some details of the satellite Mariner indicate how close-ups of the planet will be secured and sent back to the earth.
(1971) Intermediate to Sr. High.

SATELLITES - STEPPING STONES TO SPACE (20 min., color). (1959) Intermediate to Sr. High.

SOLAR FAMILY, THE (10 min., b & w). Makes an introductory study of the planets - their evolution, motions, sizes and satellites. Describes with animated drawings the evolution of the solar system according to planetesimal hypothesis, and traces the real and apparent motions of the planets. Reveals special phenomena pertaining to certain planets, and describes the planetoids, Halley's comet, and the movement of the solar system.
(1936) Jr. High to Sr. High.

SOLAR SYSTEM (18 min., 2nd Ed.). This unusual animated film combines 3-dimensional models with "you-are-there" camera techniques to create an awesome sense of drifting through outer space.
(1978) Primary, Intermediate, Jr. High, Sr. High.

SUN AND HOW IT AFFECTS US (10 min., color). A comprehensive study of the sun is presented, including the sun's size, distance from the earth, physical nature, and it's effect on life, weather, and tides on earth. A basic understanding of the probable origin and effects of the corona, prominences, flares, and sun-spots is provided through telescopic motion pictures.
(1958) Intermediate to Jr. High.

SUN AND THE SOLAR SYSTEM (20 min., color). Discusses asteroids, meteors, the sun and the nine planets in the solar system. Explains why a planet travels around the sun.
(1963) Primary to Intermediate.

SUN'S FAMILY (10 min., b & w). Explains the nature of the solar system, discussing the sun and the planets that travel about it.
(1950) Intermediate to Jr. High.

TRIP TO THE MOON (16 min., color). An imaginary rocket takes off to the moon and explores its surface. During the trip we learn many facts about conditions met in navigation to the moon. Once above the moon's surface, the film shows in detail the craters and "seas", the valleys and mountains that can be seen from the earth. The film combines animation and model photography to create a realistic illusion of a study of the moon's surface.
(1957) Intermediate to Sr. High.

UNDERSTANDING OUR UNIVERSE (11 min., color). How man has learned about the universe from ancient times until the present day is demonstrated by this film which discusses our knowledge of the universe - the solar system, Milky Way and countless other galaxies and nebulae that extend millions of light years into space.
(1957) Intermediate to Sr. High.

UNIVERSE (26 min., b & w). A triumph of film art, creating on the screen a vast, awe-inspiring picture of the universe as it would appear to the voyager through space. Realistic animation takes you out beyond our solar system, into far regions of space perceived by the modern astronomer. Beyond the reach of the strongest telescope, past moon, sun, Milky Way, into galaxies yet unfathomed, you travel on into the staggering depths of the night, astonished, spellbound at the sheer immensity of the universe. Starting point for this journey is the David Dunlop Observatory, Toronto.
(1960) Jr. High to Sr. High.

UNIVERSE (28 min.). A motion picture that explores almost inconceivable extremes of size and time - from the vast islands of stars called galaxies, to sub-atomic particles; from cosmic events that occurred billions of years ago to microcosmic events in the present that endure for only a billionth of a second.
(1978) Sr. High, College, General.

THE UNIVERSE: BEYOND THE SOLAR SYSTEM (18 min.). This film takes viewers on an exciting visual journey, beginning with our solar system and extending into and through the farthest reaches of outer space.
(1978) Sr. High.

CONSTELLATIONS

Listed below are the 88 generally recognized constellations.

Visible Above 50° North

1. Andromeda
2. Antlia
3. Aquarius
4. Aquila
5. Aries
6. Auriga
7. Bootes
8. Camelopardalis
9. Cancer
10. Canes Venatici
11. Canis Major
12. Canis Minor
13. Capricornus
14. Cassiopeia
15. Cepheus
16. Cetus
17. Columba
18. Coma Berenices
19. Corona Borealis
20. Corvus
21. Crater
22. Cygnus
23. Delphinus
24. Draco
25. Equuleus
26. Erdanus
27. Fornax
28. Gemini
29. Hercules
30. Hydra
31. Lacerta
32. Leo
33. Leo Minor
34. Lepus
35. Libra
36. Lynx
37. Lyra
38. Microscopium
39. Monoceros
40. Ophiuchus
41. Orion
42. Pegasus
43. Perseus
44. Pisces
45. Piscis Austrinus
46. Puppis
47. Pyxis
48. Sagitta
49. Sagittarius
50. Scorpius
51. Sculptor
52. Scutum
53. Serpens
54. Sextans
55. Taurus
56. Triangulum
57. Ursa Major
58. Ursa Minor
59. Virgo
60. Vulpecula

Not Visible Above 50° North

1. Apus
2. Ara
3. Caelum
4. Carina
5. Centaurus
6. Chamaeleon
7. Circinus
8. Corona Australis
9. Crux
10. Dorado
11. Grus
12. Horologium
13. Hydrus
14. Indus
15. Lupus
16. Mensa
17. Musca
18. Norma
19. Octans
20. Pavo
21. Phoenix
22. Pictor
23. Reticulum
24. Telescopium
25. Triangulum Australe
26. Tucana
27. Vela
28. Volans

21 BRIGHTEST STARS

Star	Constellation
Sirius	Canis Major
*Canopus	Carina
*Alpha Centauri	Centaurus
Arcturus	Bootes
Vega	Lyra
Capella	Auriga
Rigel	Orion
Procyon	Canis Minor
Achernar	Eridanus
*Beta Centauri	Centaurus
Betelgeuse	Orion
Altair	Aquila
Altair	Taurus
*Acrux	Crux
Spica	Virgo
Antares	Scorpio
Pollux	Gemini
Fomalhaut	Piscis Austrini
Deneb	Cygnus
*Becrux	Crux
Regulus	Leo

* not visible above 50° N.

Constellation Cans

To make a simple constellation can you need the following:

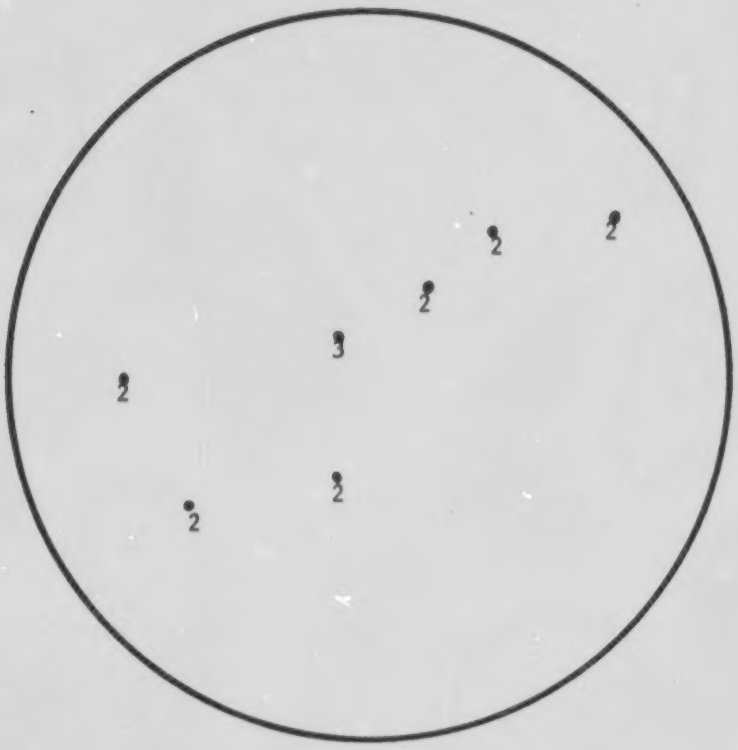
- large tin can from juice (48 oz.)
- hammer
- nails of different thicknesses (about 5)
- flashlight
- constellation discs (found on the following pages)
- scissors

Cut out a constellation disc and place it on the bottom of the can. Punch holes in the can at the positions marked for the stars. For larger stars use larger nails and for smaller stars use smaller nails to indicate the relative brightnesses of the stars.

Place the flashlight inside the can. When the room is darkened the image of the "stars" can be projected on the wall or ceiling.

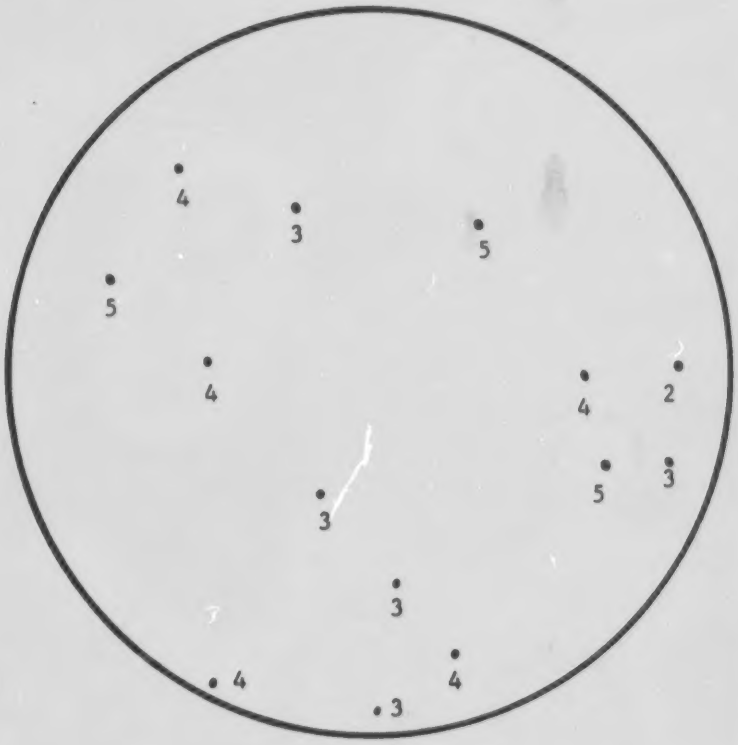
Students can project a large number of different constellations at one time on the wall and with the aid of a star chart they can simulate the sky with the constellations in the proper places in the sky.

URSA MAJOR

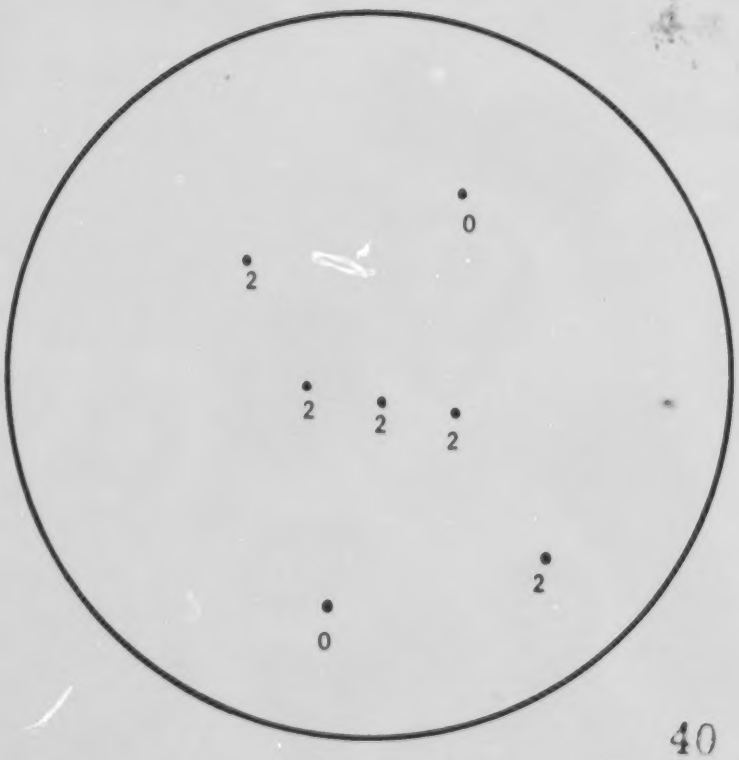


URSA MINOR

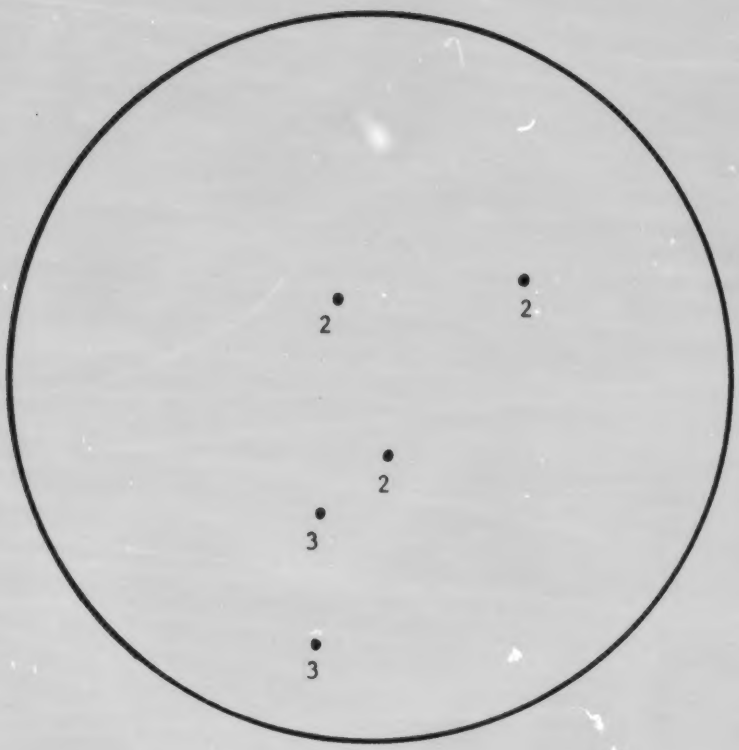
DRACO

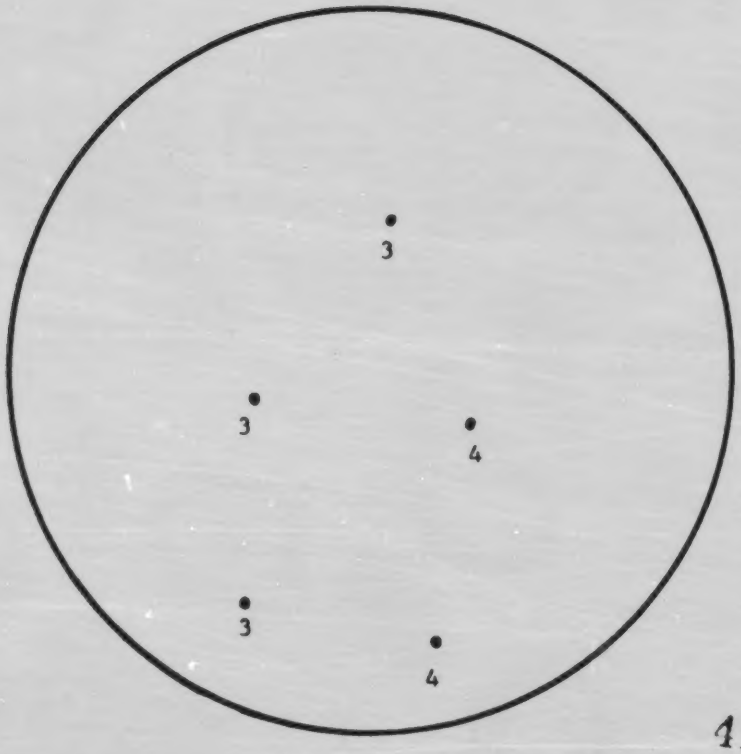


ORION



CASSIOPEIA





CEPHEUS

Constellation Slides

To make constellation slides you need the following:

-glue

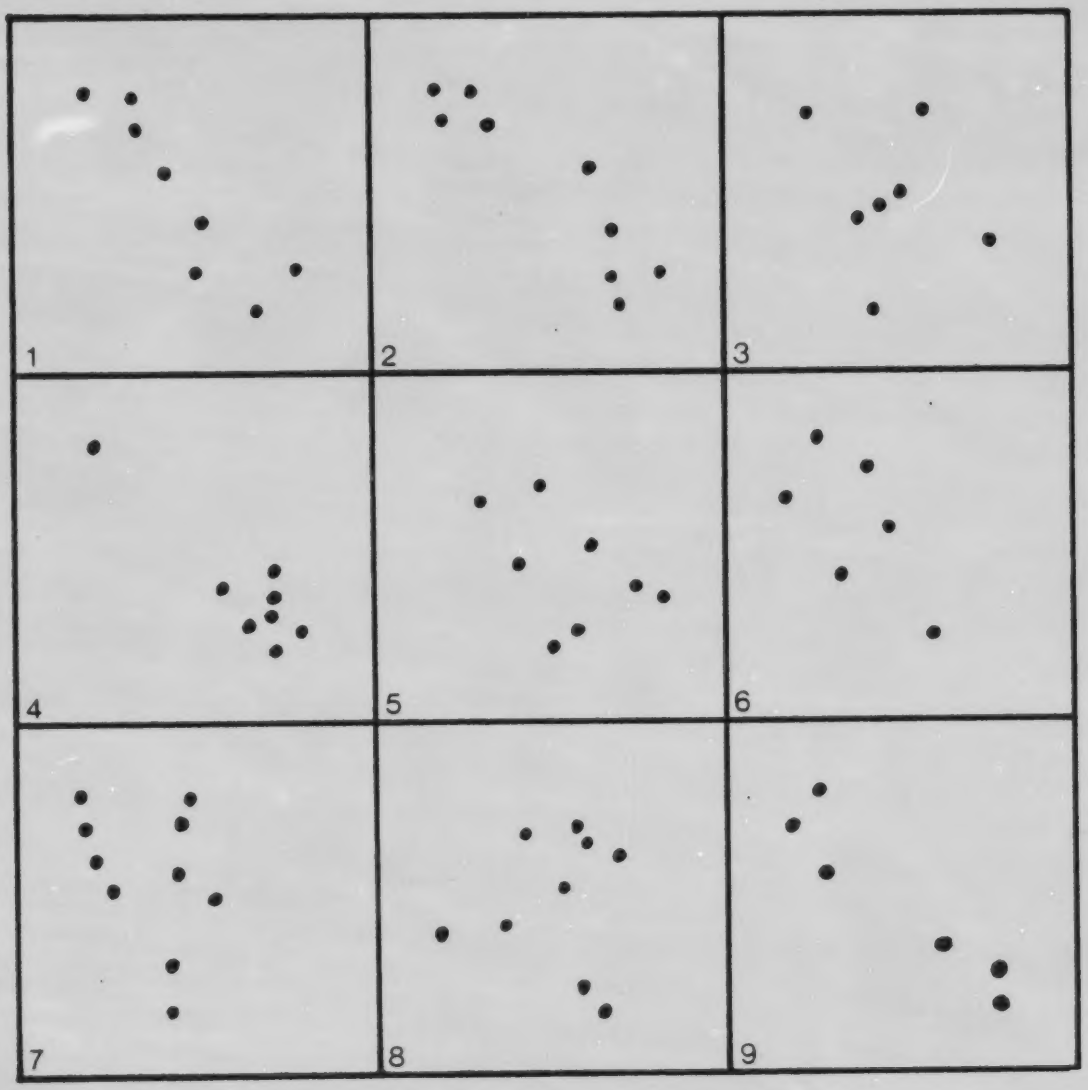
-construction paper

-scissors

-pointed object

35mm slide projector

1. Spread a thin coat of glue on the back of this sheet and affix it to a sheet of construction paper.
2. Label the constellations found in each box.
3. Separate the boxes.
4. Punch tiny holes (large enough to let light through) where stars are located.
5. Project these constellation slides in a 35mm slide projector.



ACTIVITIES

1. Challenge your friends to name the constellations correctly.
2. With a star map and using thin cardboard, make additional slides.

THE ROTATION AND REVOLUTION OF THE EARTH

The Rotation

The object of this observation is to measure the length of time required for the stars to appear to have revolved once about the Earth in order to determine the actual length of time required for the Earth to rotate once on its axis.

It is not necessary to watch the stars make a complete apparent revolution; watch them for an hour or so, and then compute how long would be required for them to turn once completely.

At the bottom of a page of 8½ x 11 paper draw a horizontal line to represent the northern horizon. Mark the center point of the line N; place NW at the left end, NE at the right. Up from the N draw a vertical at least 15 cm long. Mark the top Z. This line represents the northern half of the meridan, from the horizon to the zenith. Mark the position of Polaris about 5/9 of the way up from N. (Why 5/9?)

Early in the evening stand facing due north, at a place which can later be identified and reoccupied. Along the apparent horizon put any trees, lights, or other landmarks which show, to serve as reference points. Then draw in the sky, indicating by dots properly placed, the stars of the Big Dipper, the stars of the Little Dipper and the "W" of Cassiopeia. Record the date and time of completion of the sketch.

As late as possible, on the same evening, repeat this observation and sketch, on a second page ruled like the first, and again record the date and time.

The computation is a simple one, but first the two drawings must be measured. Using a protractor, measure the angle from the upper part of the meridan to a line drawn joining Polaris with each star of the first chart. Read this angle in a counterclockwise direction. Record the individual values of this angle in the second column of Table 1. Repeat for the second chart, recording the values in the third columnof the same table.

Subtract each of the values in column2 from the corresponding values in column 3, recording the differences in column 4. These are the angles through which the stars appeared to have moved, due to the rotation of the Earth. Add the values in column 4 and divide by 14 to obtain the mean. The values and mean may be carried to the nearest tenth of a degree. Divide this mean into 360°, and the result is the factor by which the time interval elapsing between the two observations, in minutes, is to be multipied, to give the rotation period of the Earth, in minutes. Divide by 60, to obtain the Earth's rotation period in hours, with a remainder of minutes.

The Revolution

On a third observation sheet, reled as before, repeat the observations at the same hour of the night for the first sketch, but on a night at least a month later.

Measure the sketch as before, and record the values in column 3 of Table 2. Column 2 should be filled in with the v lues of the corresponding column in Table 1.

Again take the differences, and the mean, and divide into 360°. This factor is now used to multiply the number of days elapsed from the first observation to the one just made. The result is the period of revolution of the Earth, in days.

1. Star	2	3	4
α Ursa Major			
β Ursa Major			
γ Ursa Major			
δ Ursa Major			
ε Ursa Major			
ζ Ursa Major			
η Ursa Major			
β Ursa Minor			
γ Ursa Minor			
β Cassiopeia			
α Cassiopeia			
γ Cassiopeia			
δ Cassiopeia			
ε Cassiopeia			

2. Star	2	3	4
α Ursa Major			
β Ursa Major			
γ Ursa Major			
δ Ursa Major			
ε Ursa Major			
ζ Ursa Major			
η Ursa Major			
β Ursa Minor			
γ Ursa Minor			
β Cassiopeia			
α Cassiopeia			
γ Cassiopeia			
δ Cassiopeia			
ε Cassiopeia			

ASTRONOMY PROJECT FOR SCHOOLS: PLANETS AND THE ZODIAC

Introduction

This project is designed to stimulate students' awareness of the celestial motions that aroused the curiosity of the first astronomers, thousands of years ago, and at the same time to view these motions in the more modern framework of our Solar System.

The actual observations must of course be done after dark, either individually or as a group, although observations in the planetarium might be used. In the classroom, a map of the Zodiac constellations will be drawn, and a Solar System Chart constructed, onto which the planets will be located, according to their locations in the sky. The planet locations can be up-dated from time to time by new observations.

Only normal classroom materials are required for this project, but star maps will be useful, since some of the fainter constellations are difficult to find, especially when observations are hampered by city lights.

Concepts

A visit to the Planetarium might be valuable to introduce some of the concepts involved in the project. The concepts that may be encountered, depending on the grade doing the project, are:

1. Identification of constellations, stars and planets.
2. The heavens as a sphere, with Earth at the centre; horizon circle and zenith point.
3. Motion of Moon; the zodiac circle; phases of Moon and calendars.
4. "Apparent" motion of Sun $\longrightarrow$ orbit of Earth; why we see different constellations at different seasons.
5. Positions of planets in their orbits determined by "apparent" positions against background stars.
6. Venus: morning or evening star; configurations of planets: conjunction, oppositions etc.
7. Periods of planets' revolution around Sun; Kepler's Laws.

Nightime (or Planetarium) Observations

Students can begin by learning to identify bright stars, constellations, and planets, and sketching these as they appear in the sky. The horizon, direction (N, S, E or W) and zenith point serve as references for orienting these sketches. If in doubt about the location of planets, consult an ephemeris, almanac, or call the Planetarium. With a little practice it is easy to find the planets Venus, Mars, Jupiter and Saturn. The fifth "naked-eye" planet, Mercury is usually hidden in the Sun's glare.

When the Moon is in the sky, students can sketch its phase, and attempt to determine in which constellation it is found. Originally, the Moon's path defined the Zodiac, and the Moon's phases defined the month.

In the Classroom

The Solar System Chart is constructed by drawing concentric circles to represent the planet orbits to scale around the Sun, at the center. If the Earth's orbit is one inch in radius, the others are Mercury 0.4"; Venus 0.7"; Mars 1.5"; Jupiter 5.2"; Saturn 9.5". The chart can be scaled up from these dimensions to as large as is desired.

The Zodiac constellations form a ring around the Solar System. They could simply be drawn in a ring around the outside of the Solar System Chart, but it is more effective to draw them on a strip of cardboard about 6" wide, and 6 ft. long, so that each Zodiac constellation occupies a 6" by 6" space. The ends of the cardboard are then joined to form a continuous ring, which is really part of the whole celestial sphere. In any case, it should be pointed out that the stars in this model are not to scale; they should be much further away. For instance, Pollux, one of the twin stars in Gemini and relatively nearby, should really be forty miles away on the scale of the Solar System used above.

Locating the Planets on the Chart

The Earth should be located first. Ideally, this would be done by observing which constellation the Sun is in, but obviously this is impossible. Instead the Earth's orbit can be divided into 12, going counterclockwise. Seen from the Earth, the Sun is roughly in line with the following constellations for each month:

January - Sagittarius	July - Gemini
February - Capricornus	August - Cancer
March - Aquarius	September - Leo
April - Pisces	October - Virgo
May - Aries	November - Libra
June - Taurus	December - Scorpius

To check this, the students can see which constellation is due South (on the Meridian) at midnight. (The Sun is directly opposite, below the horizon in the north.) Two hours earlier, at 10 P.M., one constellation to the East will then be due South, on the Meridian, and so on.

Example: On Feb. 15, Taurus is on the Meridian at 8 P.M., Gemini at 10, and Cancer at midnight. Therefore the Sun is opposite Cancer, in Capricornus. It is apparent why Capricornus is not seen at this time of year.

The Earth's position can be labelled with the date. Then the other planets can be located on their obits by lining them up with the appropriate constellation, as seen from Earth. Each position should be labelled with the date, and may be marked with a coloured map pin, or model of that planet.

When the observations are repeated a month or so later, it will be seen that all the planets have shifted counter-clockwise round the Sun, with the outer planets moving more slowly than the inner ones, in accordance with Kepler's Laws. If the project is done carefully over a period of a few months, the periods of the planets' orbits may be determined.

The observations might be supplemented by using binoculars or a small telescope to examine the planets, and to look for other celestial objects. There is no end to the information about particular stars and constellations, that can be provided after the students have become familiar with these.

COSMIC CALENDAR

(adapted from The Dragons of Eden by Carl Sagan)

To express a cosmic chronology is to imagine the 15 billion years lifetime of the universe compressed into the span of a single year. If one were to do so the calendar would look something like this:

January - November

January 1	The Big Bang
September 9	Origin of the Solar System
September 14	Formation of the Earth
September 25	Origin of life on the Earth
October 9	Date of oldest fossils

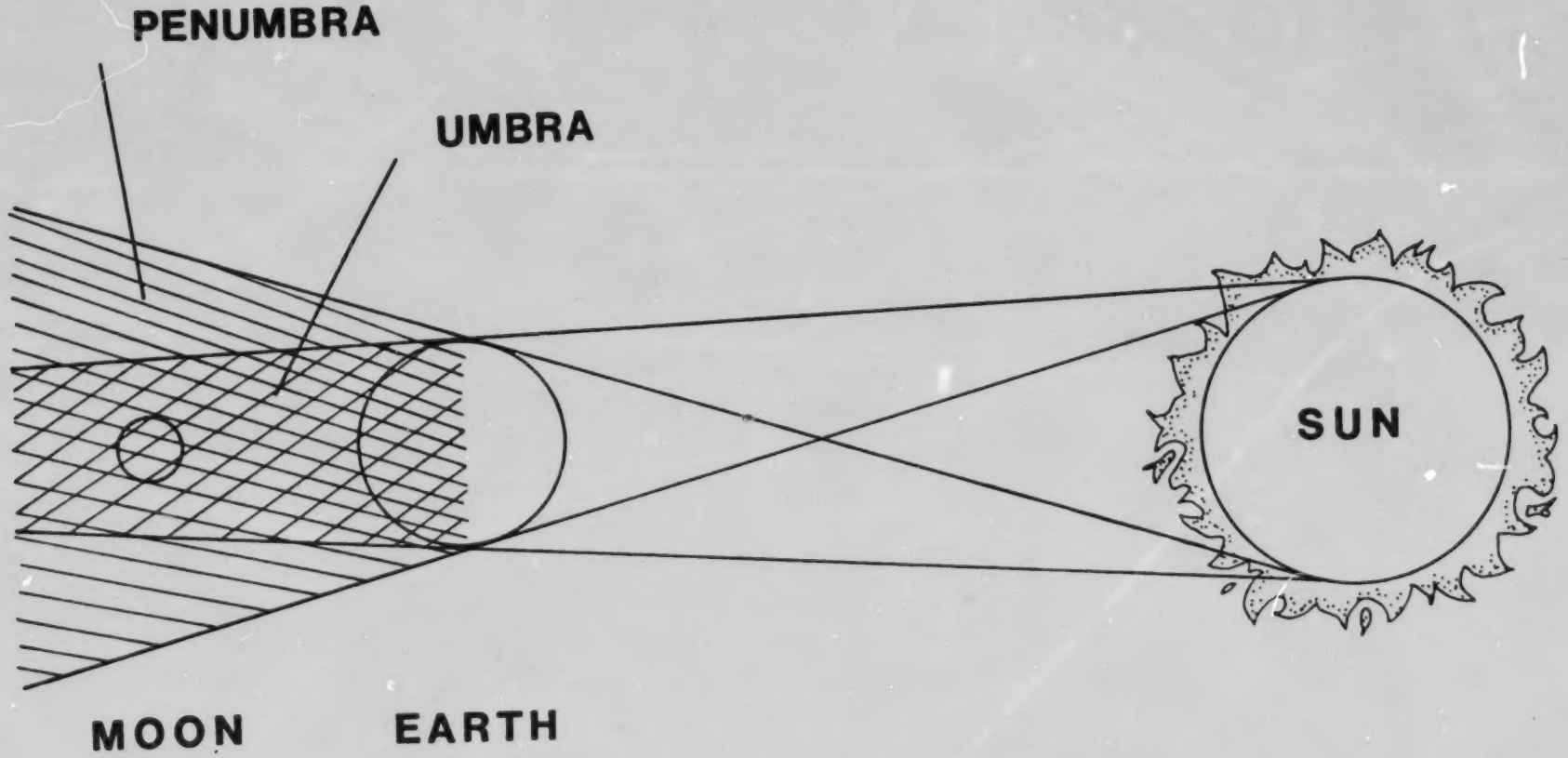
December

December 1	Significant oxygen atmosphere begins to develop on Earth
December 5	Extensive vulcanism and channel formation on Mars
December 16	First worms appear
December 19	First fish
December 20	Plants begins colonization on Earth
December 21	First insects
December 22	First amphibians
December 23	First trees, first reptiles
December 24	First dinosaurs
December 26	First mammals
December 27	First birds
December 29	First primates
December 30	First hominids, giant mammals flourish
December 31	First humans

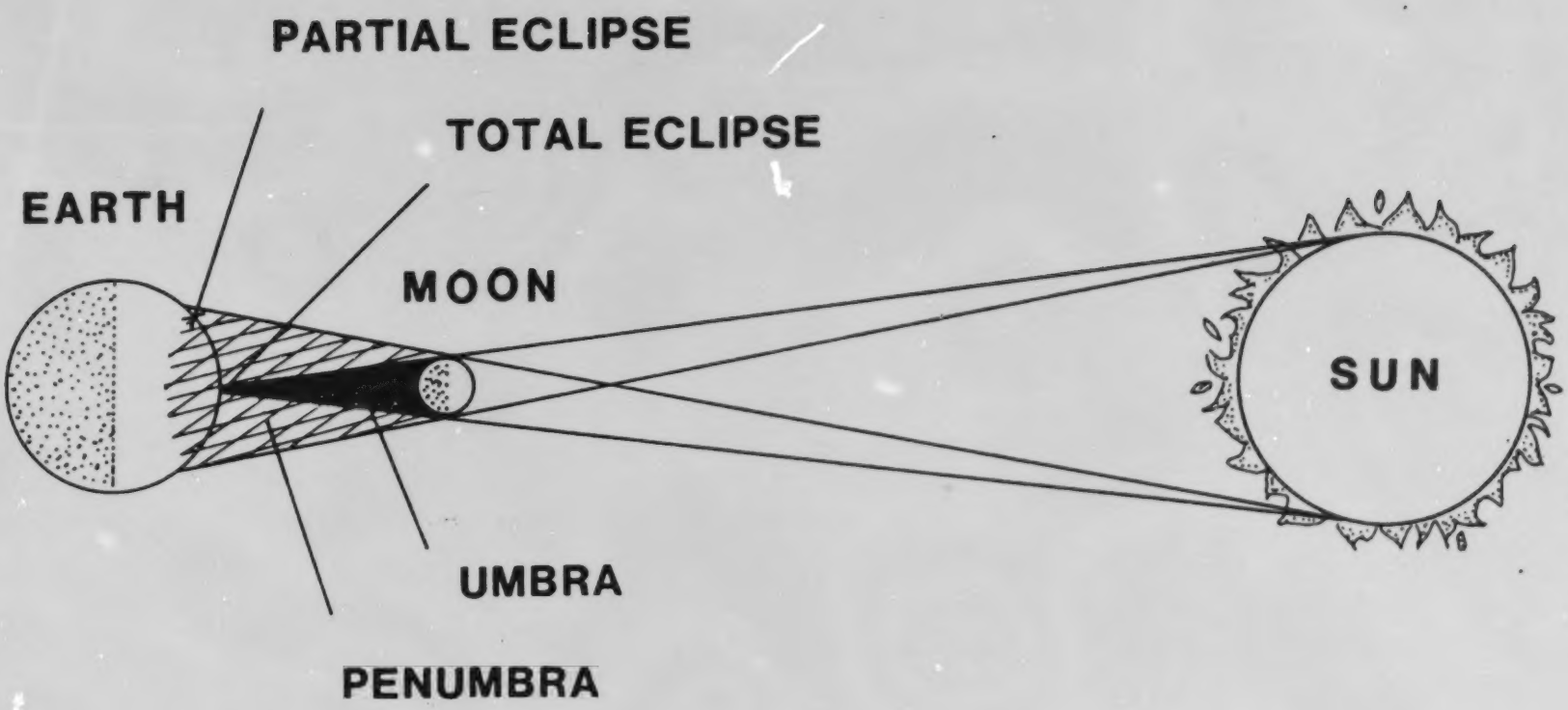
December 31

10:30p.m.	First humans
11:46p.m.	Domestication of fire by Peking man
11:56p.m.	Beginning of most recent glacial period
11:59:20p.m.	Invention of agriculture
11:59:35p.m.	First cities
11:59:53p.m.	Trojan Wars
11:59:56p.m.	Roman empire
11:59:57p.m.	Rome falls
11:59:58p.m.	Crusades
11:59:59p.m.	Renaissance in Europe, voyages of discovery from Europe
Now	Widespread development of science and technology, mankind acquires the means of self-distruction, first steps in planetary exploration and the search for extraterrestrial intelligence
The first second of h the New Year	

LUNAR ECLIPSE

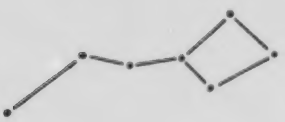


SOLAR ECLIPSE



BIG DIPPER THROUGH THE AGES

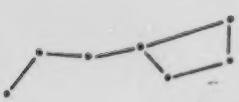
100,000 YEARS AGO



50,000 YEARS AGO

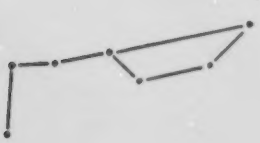
25,000 YEARS AGO

TODAY



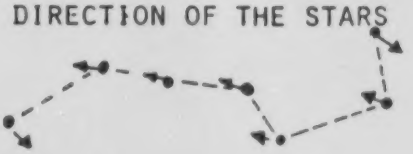
25,000 YEARS FROM NOW

50,000 YEARS FROM NOW



100,000 YEARS FROM NOW

DIRECTION OF THE STARS



LOST ON THE MOON

Your spaceship has just crash-landed on the moon. You were scheduled to rendezvous with a mother ship 200 miles away on the lighter surface of the moon, but the rough landing has ruined your ship and destroyed all the equipment on board, except for the 15 items listed below.

Your crew's survival depends on reaching the mother ship, so you must choose the most critical items available for the 200-mile trip. Your task is to rank the 15 items in terms of their importance for survival. Place number one by the most important item, number two by the second most important, and so on through number 15, the least important.

Difference	NASA		
_____	_____	_____	Box of matches
_____	_____	_____	Food concentrate
_____	_____	_____	Fifty feet of nylon rope
_____	_____	_____	Parachute silk
_____	_____	_____	Solar-powered portable heating unit
_____	_____	_____	Two .45-caliber pistols
_____	_____	_____	One case of dehydrated milk
_____	_____	_____	Two 100-pound tanks of oxygen
_____	_____	_____	Stellar map (of the moon's constellation)
_____	_____	_____	Magnetic compass
_____	_____	_____	Five gallons of water
_____	_____	_____	Signal flares
_____	_____	_____	First-aid kit containing injection needles
_____	_____	_____	Solar-powered FM receiver-transmitter
_____	_____	_____	Self-inflating life raft

LOST ON THE MOON (Key)

Items	NASA's Reasoning	NASA's Rank
Box of matches	No oxygen on moon to sustain flame, useless	15
Food concentrate	Efficient means of supplying energy requirements	4
Fifty feet of nylon rope	Useful in scaling cliffs, tying injured together	6
Solar-powered portable heating unit	Only used on dark side	13
Two .45 caliber pistols	Possible means of self-propulsion	11
One case of dehydrated Pet milk	Bulkier duplication of food concentrate	12
Two 100 pound tanks of oxygen	Most pressing survival need	1
Stellar map (of the moon's constellation)	Primary means of navigation	3
Self-inflating life raft	CO_2 bottle in military raft may be used for propulsion	9
Magnetic compass	Magnetic field on moon is not polarized; worthless for navigation	14
Five gallons of water	Replacement of tremendous liquid loss on lighted side	2
Signal flares	Distress signal when other ship is sighted	10
First aid kit containing injection needles	Needles for vitamins, medicines etc., will fit special hole in NASA space suits	7
Solar powered FM receiver-transmitter	For communication with mother ship; but FM requires line-of-sight transmission and short range	5
Parachute silk	Can be used as sling or dressings for injuries	8

Error points are the difference between your rank and NASA's.

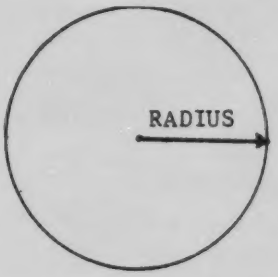
Scoring

0-25	excellent	46-55	fair
26-32	good	56-70	poor
33-45	average	71-112	very poor, suggest possible faking or use of earth bound logic.

RADIUS & DIAMETER

The diameter is the distance across the circle.

The radius is the distance from the center of the circle to the outside of the circle.



The radius is always one half the diameter

Questions:

1) Here are the diameters of circles, you give the radius.

   Diameter is 10 cm, radius is 5 cm

   Diameter is 16 cm, radius is ___ cm

   Diameter is 8.4cm, radius is ___ cm

   Diameter is 7.2cm, radius is ___ cm

2) Given the radius figure out the diameter for a circle.

   Radius is 7 cm, diameter is 14 cm

   Radius is 5.3cm, diameter is ___ cm

   Radius is 3.2cm, diameter is ___ cm

   Radius is 2.1cm, diameter is ___ cm

3) Using a radius of 3 cm, draw a circle.

4) Draw a circle that will have a diameter of 4.8 cm.

MAKING SCALE DIAGRAMS OF THE SOLAR SYSTEM

Complete the following table using a scale of 1 centimeter for every 10,000 kilometers. This means that you will be reducing the size of the planets.

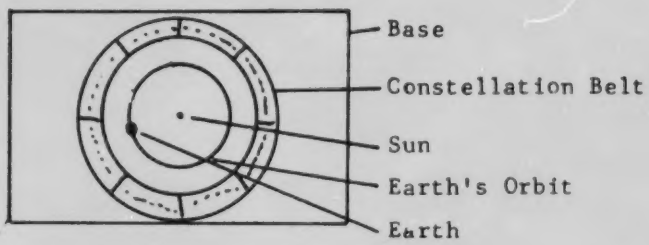
PLANETS AND SOME LARGE SATELLITES	ACTUAL DIAMETER IN KILOMETERS (KM)	SCALE DIAMETER (CM)	SCALE RADIUS (CM)
Mercury	4,900	.49	.25 (divide by 2)
Venus	12,100		
Earth	12,800		
Moon	3,500		
Mars	6,800		
Jupiter	143,000		
Io	3,700		
Europa	2,900		
Ganymede	5,500		
Collisto	4,500		
Saturn	120,000		
Titan	4,800		
Uranus	50,800		
Neptune	48,600		
Pluto	5,800		

On the following page draw the scaled planets and satellites using the proper dots.

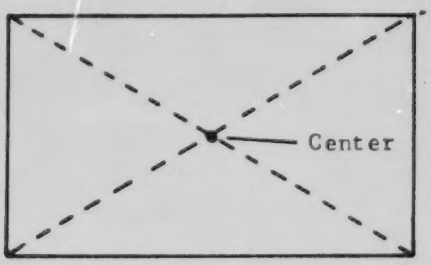
Mercury
Venus
Earth
Moon
Io
Europa
Jupiter
Ganymede
Collisto
Mars
Uranus
Saturn
Titan
Neptune
Pluto

CONSTELLATION POSITIONS

This is to construct a three-dimensional model showing the constellations that can be seen along the Earth's orbit. These are known as the constellations of the zodiac.

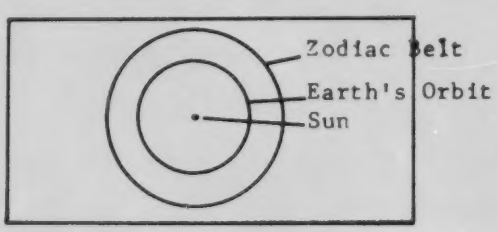


1. Find the middle of your poster paper by drawing lines from opposite corners.



2. Draw the elliptical orbit of the Earth around the Sun using two pins and a loop of string. One pin will be at the centre of the Sun, the other will be 2.5 cm from the Sun towards the bottom of the poster paper. Your loop of string should be 15 cm long.

3. Select a suitable radius for your zodiac belt as it goes around the Sun. Draw a large circle using a string, a pin and the Sun as the center of the circle.

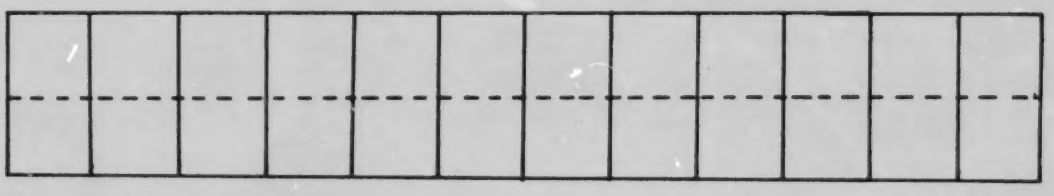


4. Now you must calculate the length of a paper strip that must go around the circumference of your circle. It is given by the formula:

circumference = 2 r where = 3.14
r = your radius

5. Cut your length of paper the right length and about 10 cm wide. Draw a line down the centre and label it the ECLIPTIC.

6. Divide your strip into 12 equal parts using pencil lines.

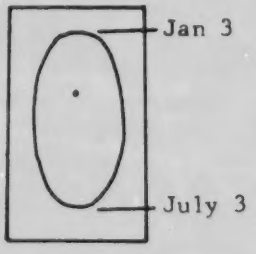


7. Starting from the right end of your strip you can begin to label the dates of the different zodiac constellations (obtain this from your local newspaper).

8. The constellations lie either slightly above or slightly below the ecliptic. This can be measured in degrees.

1. Aries	- 7-10° above	7. Libra	- 8° above to 8° below
2. Taurus	- 5° above to 5° below	8. Scorpius	- 0° to 20° below
3. Gemini	- top is 10° below	9. Sagitarrius	- 2° above to 12° below
4. Cancer	- on the line	10. Capricorn	- 10° above to 7° below
5. Leo	- top is 10° above	11. Aquarius	- 0° to 11° below
6. Virgo	- between 15° and 0° above	12. Pisces	- 0° to 10° below

9. Turn the strip into a loop and attach it to your poster paper. Remember the Earth is furthest from the Sun on July 4th and closest to the Sun on January 3rd.



This project will teach:

(1) the zodiac
(2) the ecliptic
(3) the elliptical orbits
(4) geometry

along with astronomy.

ELLIPSES

To draw an ellipse you need the following:

- 2 thumbtacks
- pencil
- string
- metric ruler
- cardboard or wooden platform
- white drawing paper

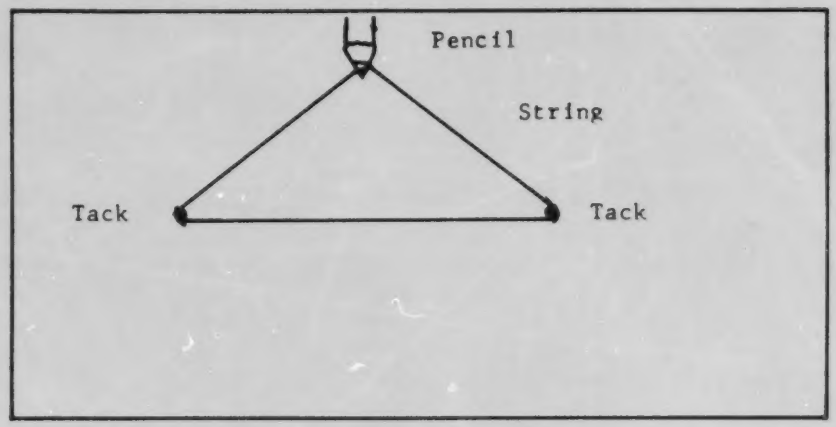
1. Place a sheet of white drawing paper on the top of a cardboard or wooden platform

2. In the middle of the paper, place 2 thumbtacks 6 cm. apart.

3. Ties the ends of a string together forming a loop with a circumference of 20 cm.

4. Loop the string tightly around the thumbtacks and stretch it tightly using a pencil.

5. Trace out the path followed by the pencil around the thumbtacks keeping the string tightly stretched at all times.



6. The figure drawn is called an ellipse. The thumbtacks are the focus points. Label these points A and B. Label three points anywhere on the ellipse C_1, C_2, and C_3.

7. Measure the lengths of the lines AC_1; AC_2; AC_3; BC_1; BC_2; and BC_3 in mm. and fill in the chart on the following page.

Position of C	Length of AC (mm)	Length of BC (mm)	Sum of AC and BC (mm)
C_1			
C_2			
C_3			

8. Draw another ellipse with the focus points 3 cm. apart instead of 6 cm. Repeat the procedure done in Step 7 and complete the following chart.

Position of C	Length of AC (mm)	Length of BC (mm)	Sum of AC and BC (mm)
C_1			
C_2			
C_3			

9. Compare the results and what general statement can be said with regard to the sum of any two lines drawn from the focus point to any point on an ellipse.

ORBITS OF THE PLANETS

This activity use the procedures learned in the activity on drawing an ellipse and applies it to drawing a scale model of the solar system.

The materials you need are the following:

- 2 thumbtacks
- string
- cardboard
- 2 pieces of drawing paper
- metric ruler

1. Set use the materials used to draw an ellipse.
2. Using the table below giving string loop sizes and distances between tacks, draw concentric ellipses showing the paths travelled by the planets around the Sun.

Note:
Due to the immense differences in distances between the inner and outer planets it is not practical to use the same scale for all planets. Use one sheet of paper for the inner planets and one for the outer planets.

The Inner Planets (Scale: 1cm = 15,000,000 km)

Planet	Loop Size	Distance Between Tacks
Mercury	9.0 cm	1.50 cm
Venus	14.0 cm	0.08 cm
Earth	19.0 cm	0.32 cm
Mars	31.5 cm	2.70 cm

The Outer Planets (Scale: 1 cm = 300,000,000 km)

Jupiter	5.2 cm	0.24 cm
Saturn	9.5 cm	0.48 cm
Uranus	19.0 cm	0.88 cm
Neptune	28.8 cm	0.32 cm
Pluto	46.7 cm	9.50 cm

PLANETARY ORBITS

This exercise studies the motion of an object moving in an elliptical path around a star

The materials you need are the following: - a protractor

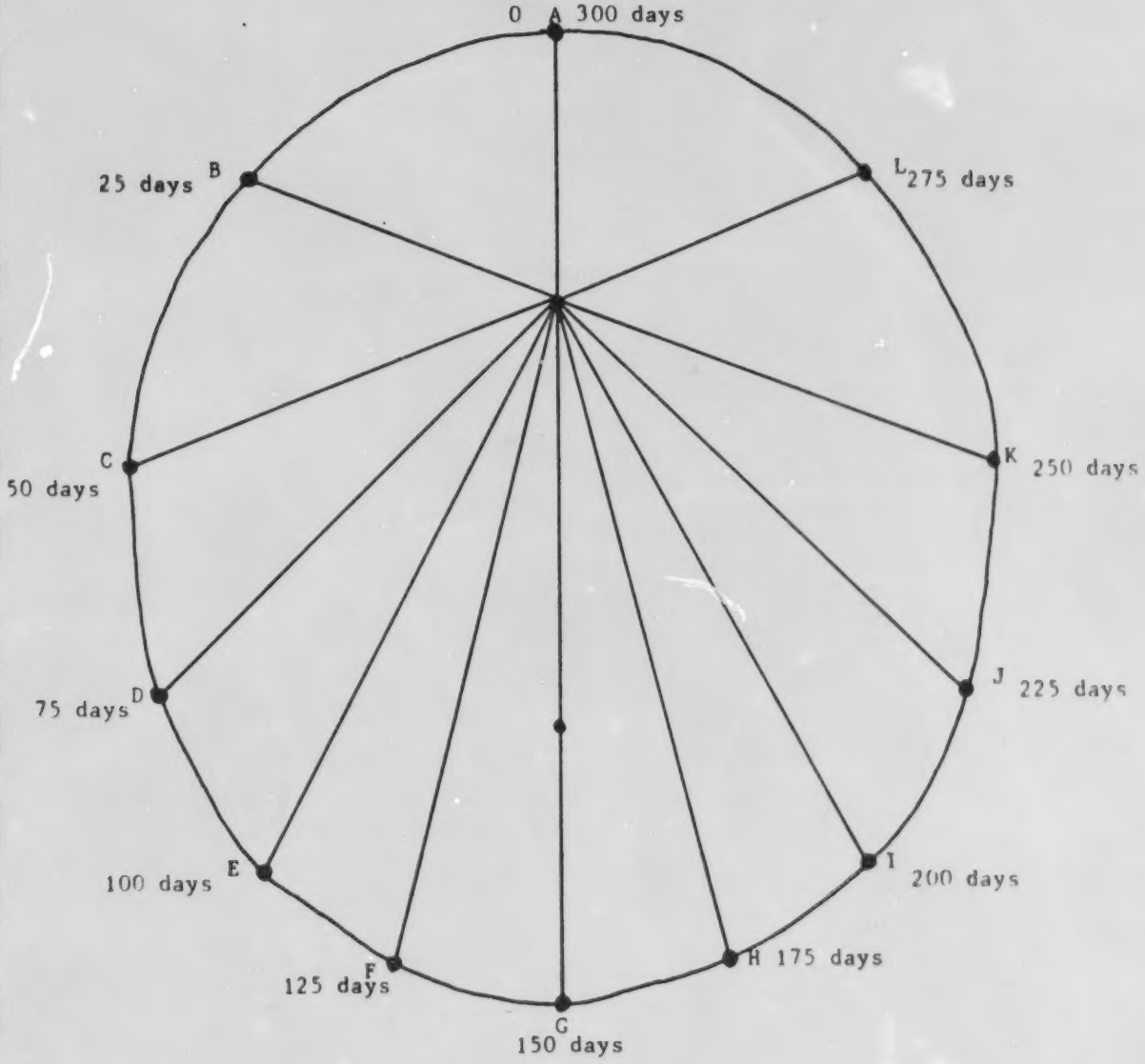
1. Look at the page entitled "The Orbit of Planet X". This planet moves around its star in 300 days. Positions of the planet are marked off in 25 day intervals.

2. Using a protractor measure the angles formed from the focus where the star is to the position of the planet every 25 days. Record your results in the data table below.

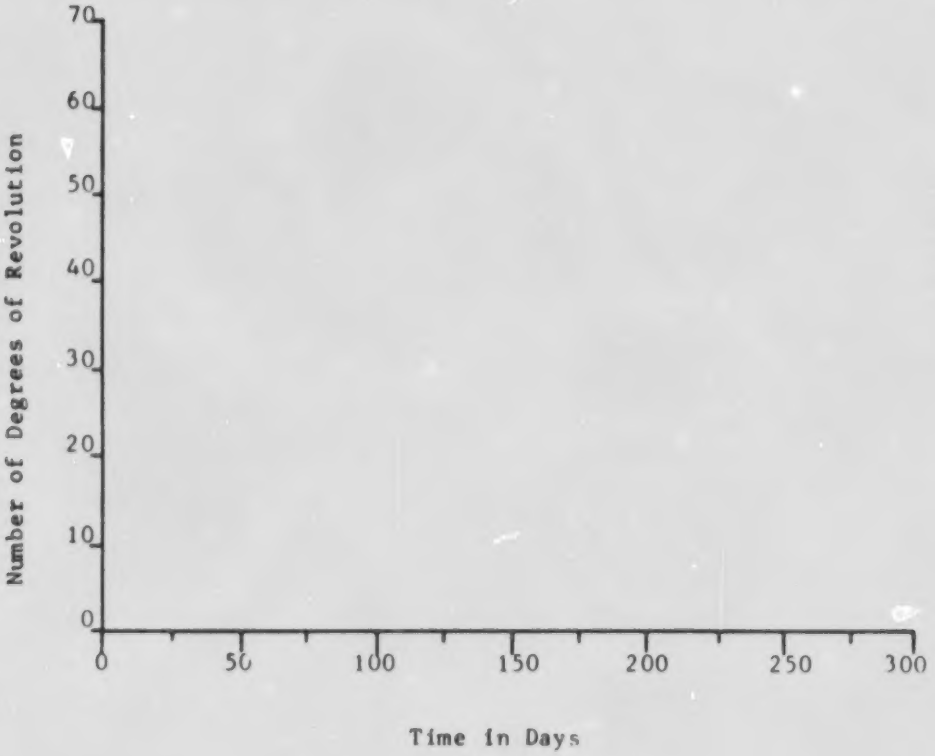
DATA TABLE

Time Travelled (25 day intervals)	Number of Degrees Moved
A-B	
B-C	
C-D	
D-E	
E-F	
F-G	
G-H	
H-I	
I-J	
J-K	
K-L	
L-A	

The Orbit of Planet X



Graph the results on the graph below:



Questions:

1. At what position is the planet at perihelion? _____
2. At what position is the planet at aphelion? _____
3. At which point in its orbit is it travelling the fastest? _____
4. At which point in its orbit is it travelling the slowest? _____

COLOUR TEMPERATURE RELATIONSHIP OF STARS

When an object produces its own light, we call that object luminous. The colour of a luminous objects tells us what temperture it is. For example, an object which is a dull red colour is not as hot as an object which is bright red. A luminous object which is yellow in colour is much hotter than a bright red object. If the colour of a luminous object is white, then the temperature is very, very hot. The hoyyest of all luminous objects is blue-white.

If two objects are yellow, they may not have exactly the same colour. One may be dark yellow while the other may be a light yellow. This is the same with stars. All yellow stars are not the same yellow. The exact colour depends upon the star's temperature.

In astronomy, we can distinguish a white star and a blue-white star, or a yellow star from a red star, by the use of the star's spectrum. It is not easy for our eyes to distinguish between the various colours of the stars. The spectrum is very sensitive. We assign the following letters to the stars to tell us the star's spectral class (its colour):

W O B A F G K M N S

You can remember these letters this way:

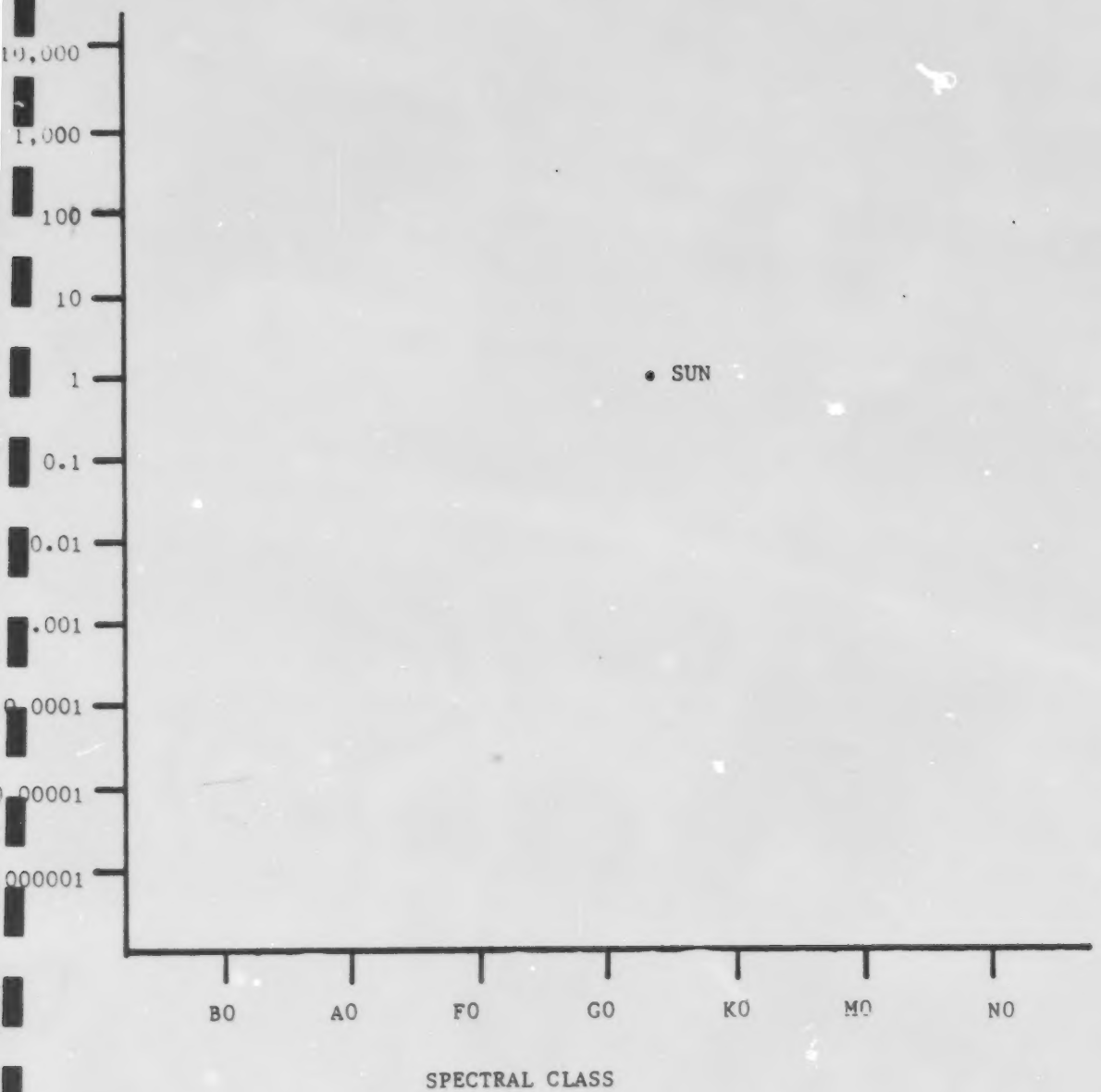
Wow O Be A Fine Girl Kiss Me Now Sweetie

A super hot blue-white star is a W star.
A very hot white star is an O star.
A hot white star is a B star.
A yellow star like our Sun is a G star.
Hot red stars are M stars, and cool red stars are N and S stars.

For each of the stars listed on the next page, line up the luminosity with the spectral class on the graph provided. Notice how the dot for the Sun matches 1 for luminosity and G for spectral class. Do not write the names of each of the stars on the graph.

STAR	TEMPERATURE IN °K	NUMBER OF TIMES THE SUN'S LUMINOSITY	SPECTRAL TYPE
Sirius	10,000	23	A1
Canopus	7,000	1,500	F0
Alpha Centauri	5,800	1.3	G2
Arcturus	4,500	90	K2
Vega	10,700	60	A0
Capella	5,900	150	G0
Rigel	11,800	40,000	B8
Procyon A	6,500	7.6	F5
Betelgeuse	3,200	17,000	M2
Achernar	14,000	200	B3
Beta Centauri	21,000	3,300	B1
Altair	8,000	10	A7
Alpha Crucis	21,000	2,700	B1
Aldebaran	4,200	90	K5
Spica	21,000	1,900	B1
Antares	3,400	4,400	M1
Pollux	4,900	3,300	K0
Fomalhaut	9,500	14	A3
Deneb	9,900	40,000	A2
Beta Crucis	22,000	6,000	B0.5
Regulus		70	A0
Alpha Centauri A	5,800	1.3	G2
B	4,200	0.36	K5
C	2,800	0.00006	M5
Barnard's Star	2,800	0.00044	M5
Wolf 359	2,700	0.00002	M4
Lalande 21185	3,200	0.0052	M2
Sirius A	10,400	23	A1
B	10,700	0.008	A2
Luyten 726-8A	2,700	0.00006	M6
726-8B	2,700	0.00004	M6
Ross 154	2,800	0.0004	M5
248	2,700	0.00011	M6
128	2,800	0.00033	M5
Epsilon Eridani	4,500	0.30	K2
Luyten 789-6	2,700	0.00012	M6
61 Cygni A	4,200	0.083	K5
61 Cygni B	3,900	0.040	K7
Procyon A	6,500	7.6	F5
Ptocyon B	7,400	0.0005	F2
Epsilon Indi	4,200	0.13	K5

LUMINOSITY VS. SPECTRAL CLASS

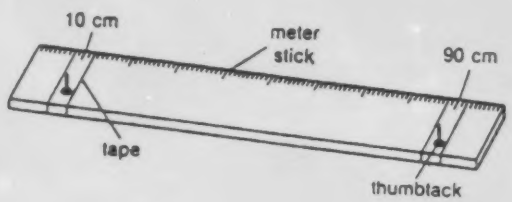


DISTANCE MEASURING DEVICE

To construct a distance measuring device you will need the following materials:

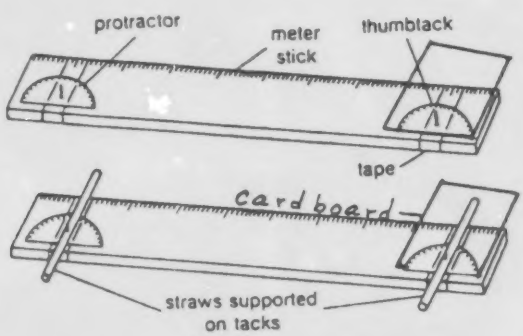
- a metre stick
- 2 thumbtacks
- 2 protractors
- masking tape
- one piece of cardboard $15cm^2$ or larger
- 2 straws

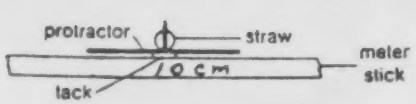
1. Place two thumbtacks upside down on a metre stick, one at the 10cm mark and one at the 90cm. Using the masking tape, stick them to the metre stick as in the diagram below:

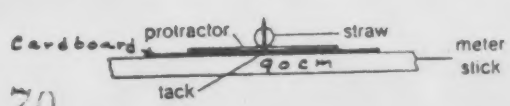


2. Place a protractor on the tack at the 10cm mark by drilling a small hole in the protractor to prevent it from breaking and putting the protractor over the tack. Tape the protractor down with masking tape so that it is parallel with the edge of the metre stick.

3. On the tack at the 90cm mark place a square piece of cardboard. Place a protractor on the top of the cardboard and tack and tape it down as in step 2.





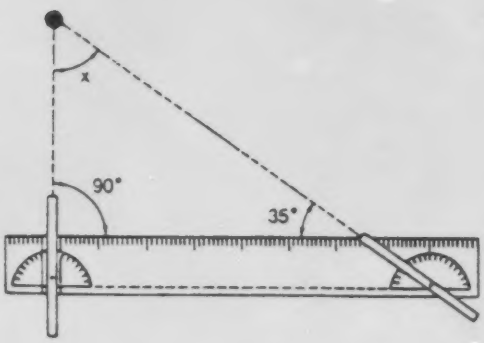


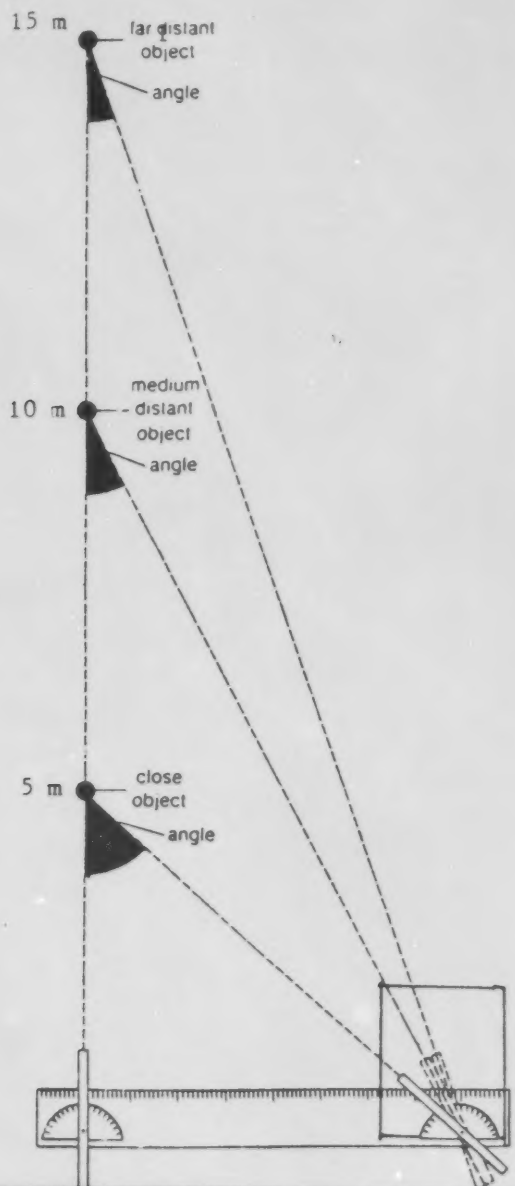
Calibration

To calibrate the distance measuring device, place objects at known distances of 1 metre, 3 metres, 5 metres, 10 metres, 15 metres and 20 metres from you.

1. Line the object 1 metre away from your distance measuring device so that the straw at the 10 cm mark lies directly on the top of the 90° mark of the protractor.

2. Line the straw at the 90 cm mark up with the object and place a mark on the cardboard directly underneath the straw. Record the information along with the angle (x) it marks with the base of the protractor. This angle is called the angle of parallax. An example is illustrated below:



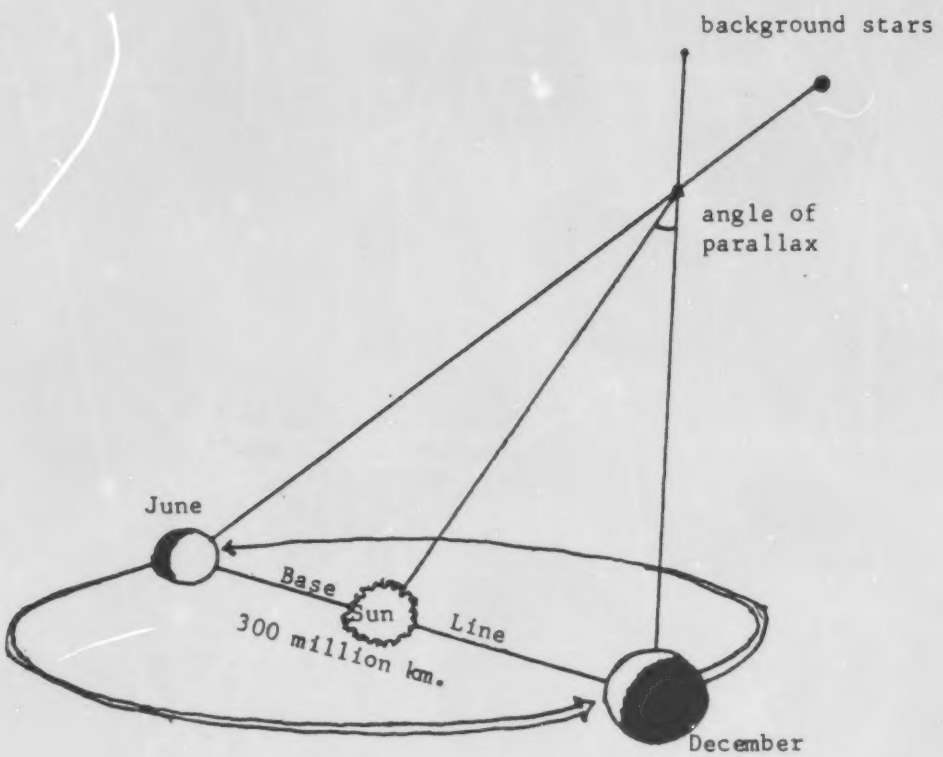


3. Repeat the above step for each of the known distances. Calibrate the cardboard with each of these distances and calculate the angle of parallax. Record your results in the following table.

DISTANCE MEASURED (METRES)	ANGLE AT 10 CM	ANGLE AT 90 CM	TOTAL	ANGLE OF PARALLAX
1				
3				
5				
10				
15				
20				

Measuring Distances to Stars

To measure distances as far away as stars an enormous base line is needed. The longest baseline possible is the distance across the orbit of earth. To use this distance astronomers sight stars six months apart. At six month intervals the earth is at opposite positions in its orbit. Even with this large base line the parallax effect is very small. It is possible to measure the distances to the nearest stars in this manner using very fine instruments.



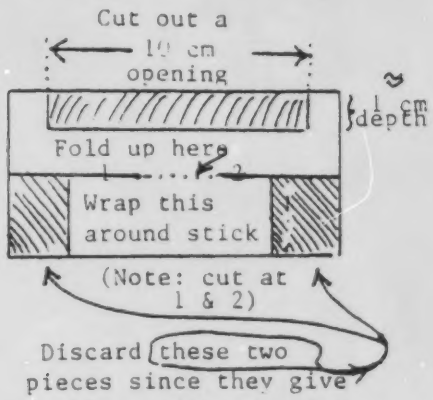
ANGLE MEASUREMENTS

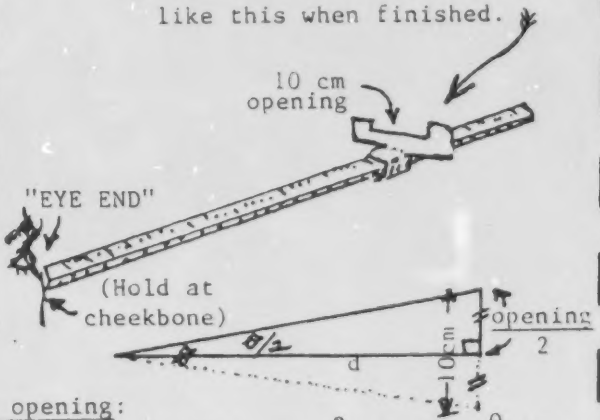
MAKING A CROSS STAFF:

TABLE OF DISTANCES

Angle Subtended at the EYE by a 10 cm opening	Distance Along Staff from the EYE for a 10cm opening
50°	10.72 cm
40	13.74
30	18.66
24	23.52
20	28.36
18	31.57
16	35.58
14	40.72
12	47.57
10	57.15
9	63.53
8	71.51
7	81.75
6 (θ)	95.41 (d)

USING A 5" x 3" FILE CARD:





STEP ONE:

For a 10 cm opening:

Formula: $d = \frac{\text{opening}}{2} \cot.\frac{\theta}{2} = 5\cot.\frac{\theta}{2}$ cm

Tape a double thickness of masking tape to a meter (or yard) stick. (double thickness helps hide the numbers written on the stick)

STEP TWO:

Using the table given above, mark on the tape the ANGLES, using the distance placements given in the table (e.g. a line for 30° would be made at a distance of 18.66 cm from the end marked "PLACE CHEEK HERE" which is the "eye" end. Mark the line 30°. Readings other than those in the table can be extrapolated, keeping in mind the changing scale.)

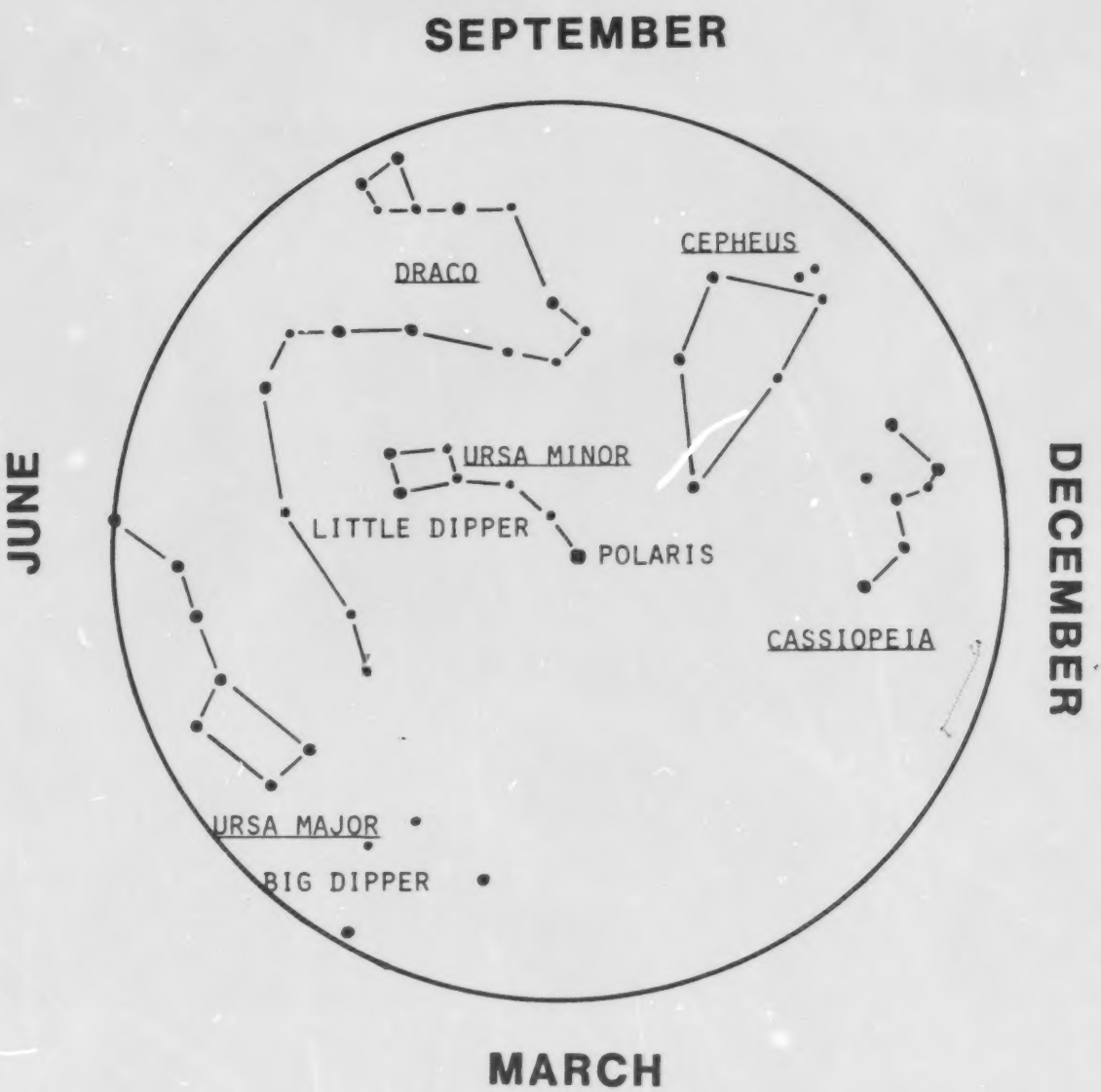
STEP THREE:

Using a 5" x 3" filing card, cut an opening of 10 cm along the side, and then cut and attach the card to the staff as shown above on the right.

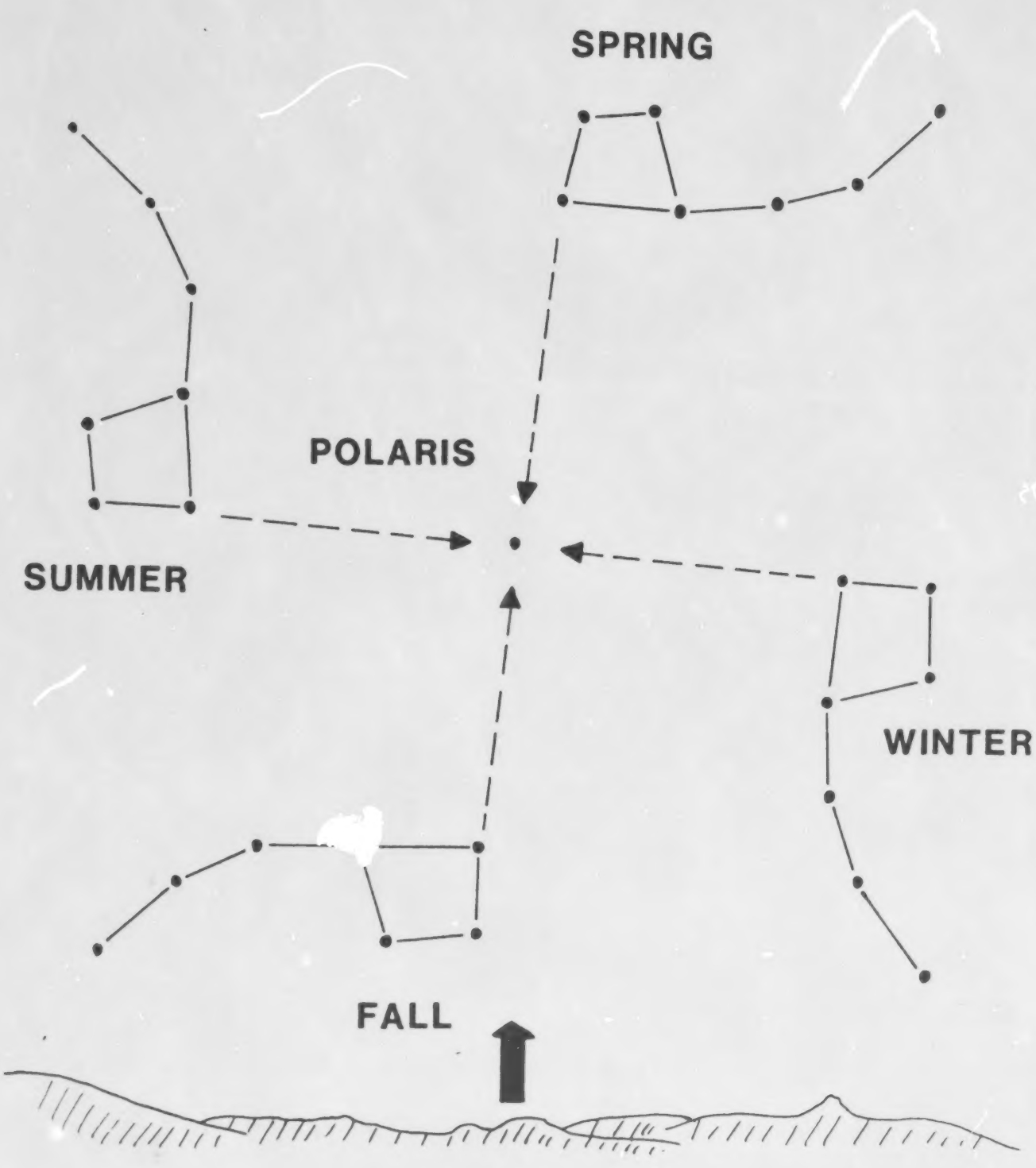
STEP FOUR:

Your instructor will demonstrate both how to make the card and to use the "cross staff."

NORTH POLAR CONSTELLATIONS



BIG DIPPER IN DIFFERENT SEASONS

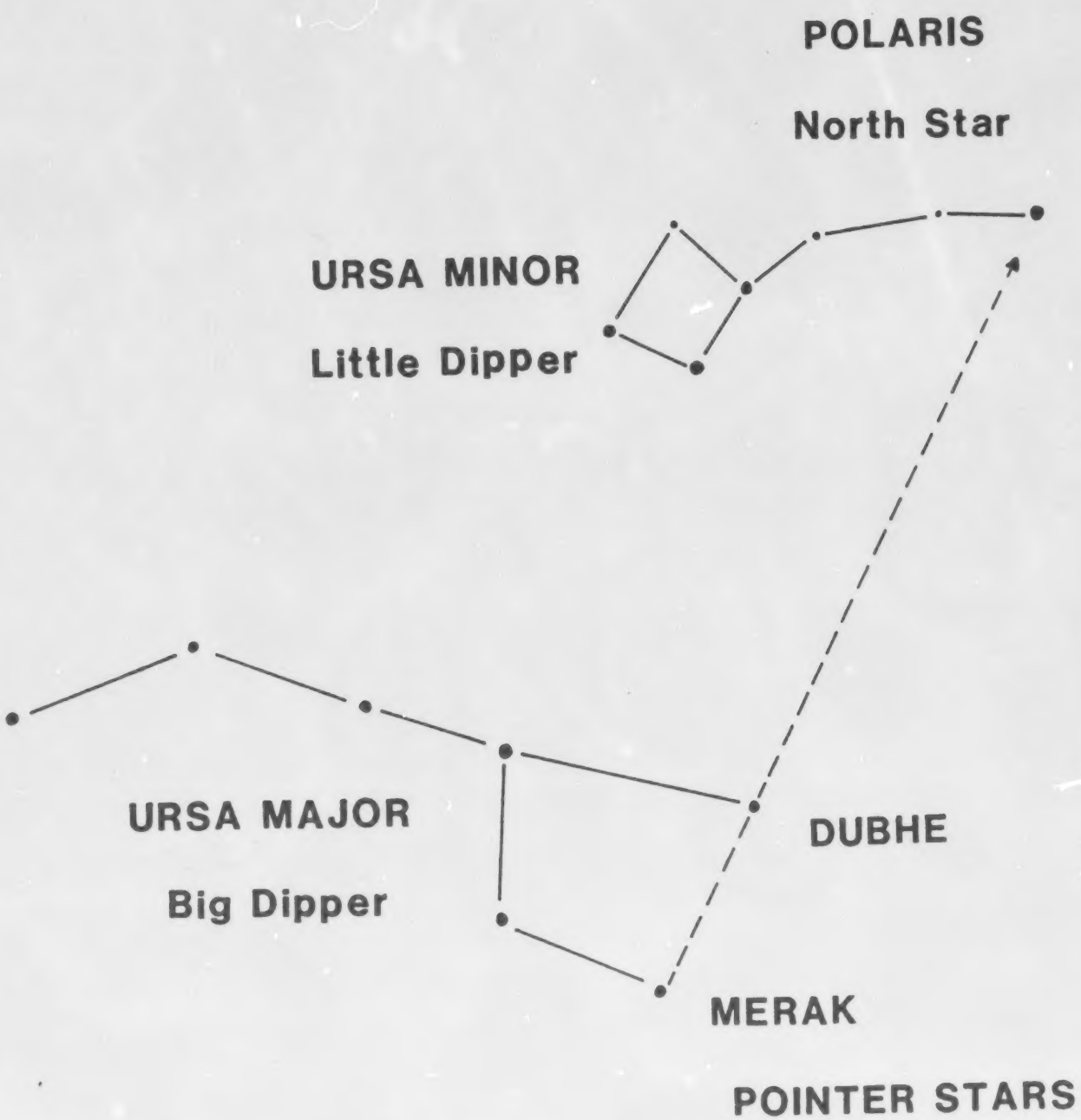


LOOKING NORTH AT EIGHT P.M.

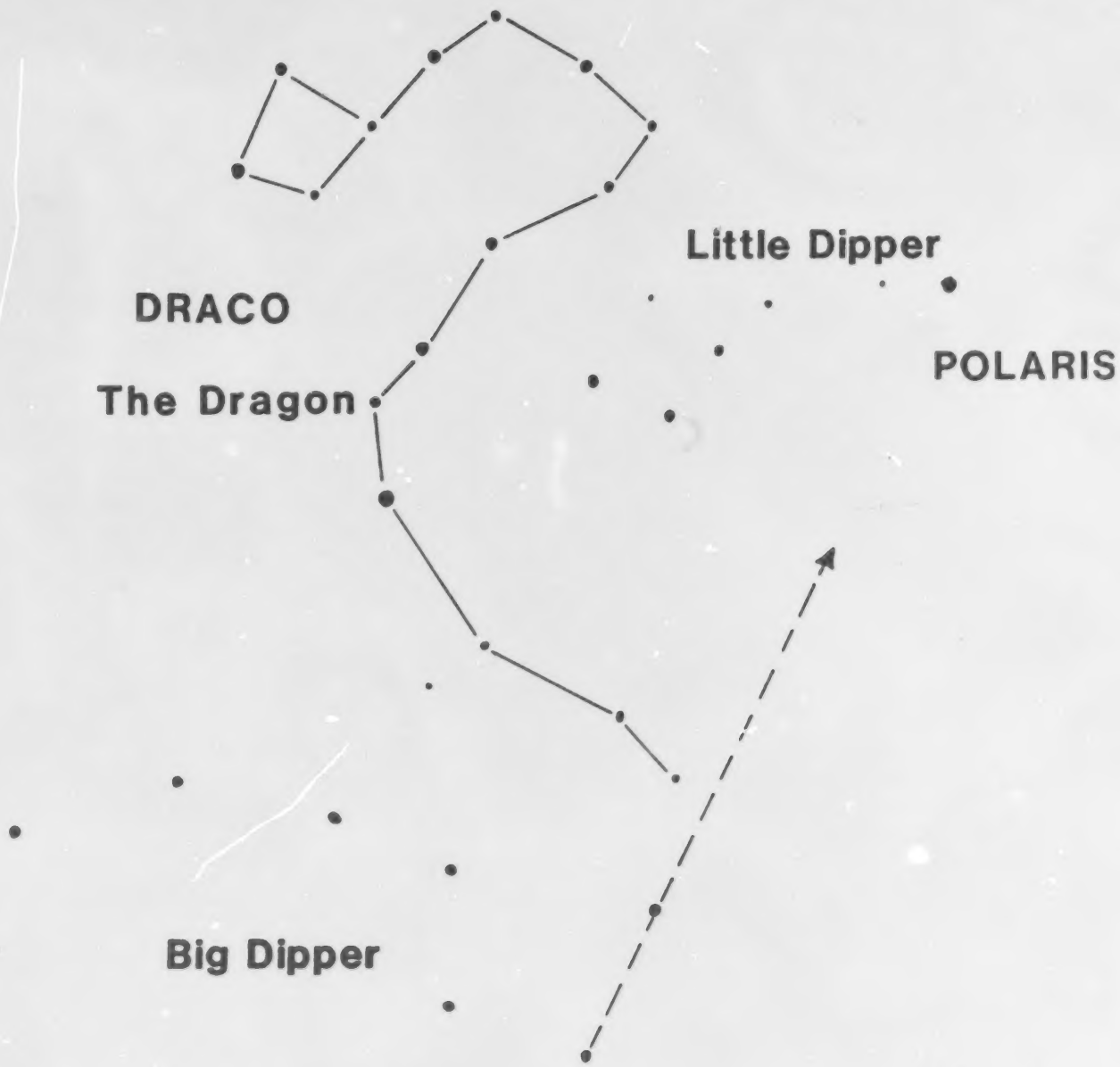
THE BIG DIPPER

A Part of the Constellation Ursa Major

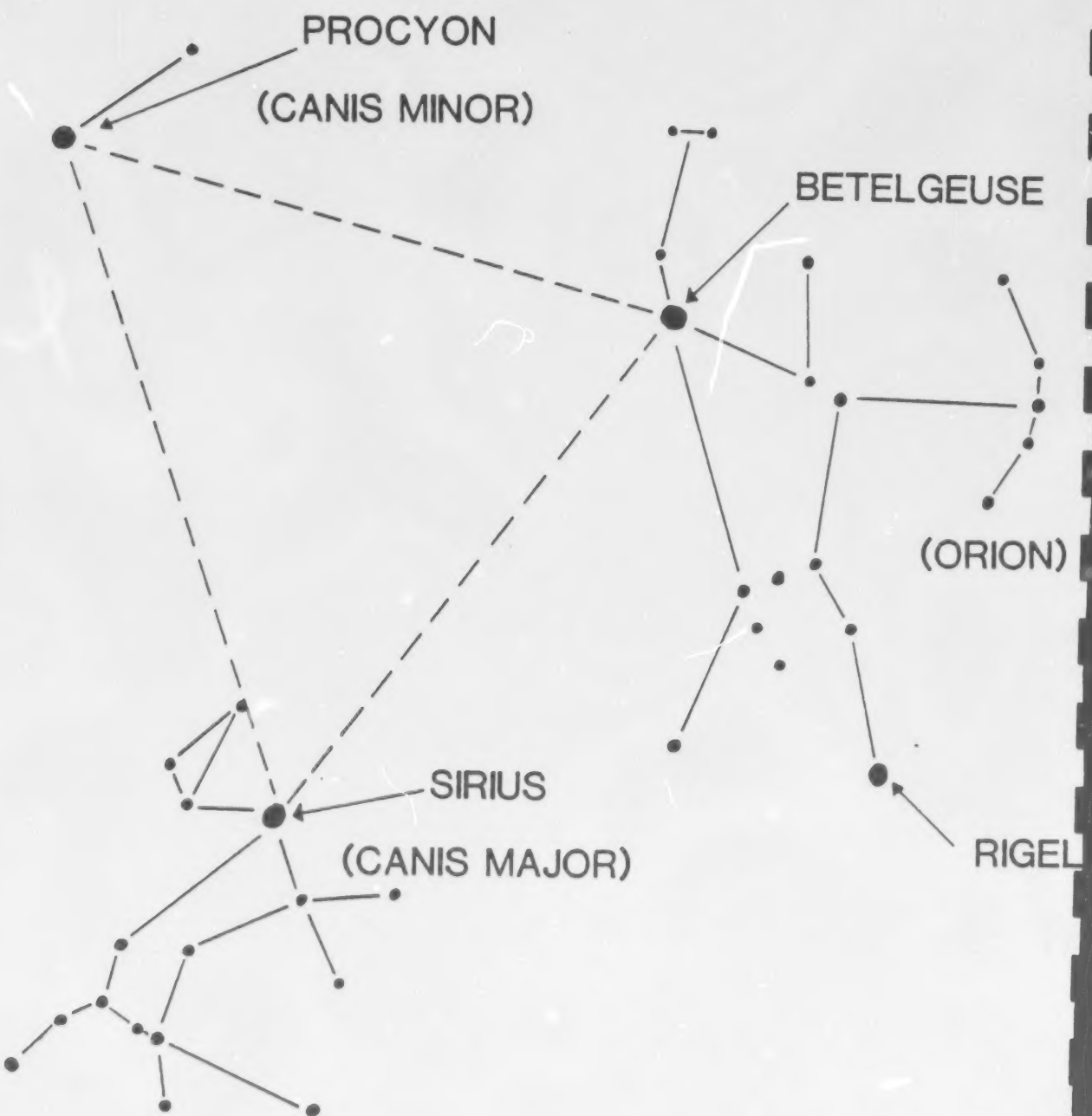
FINDING THE NORTH STAR



FINDING DRACO

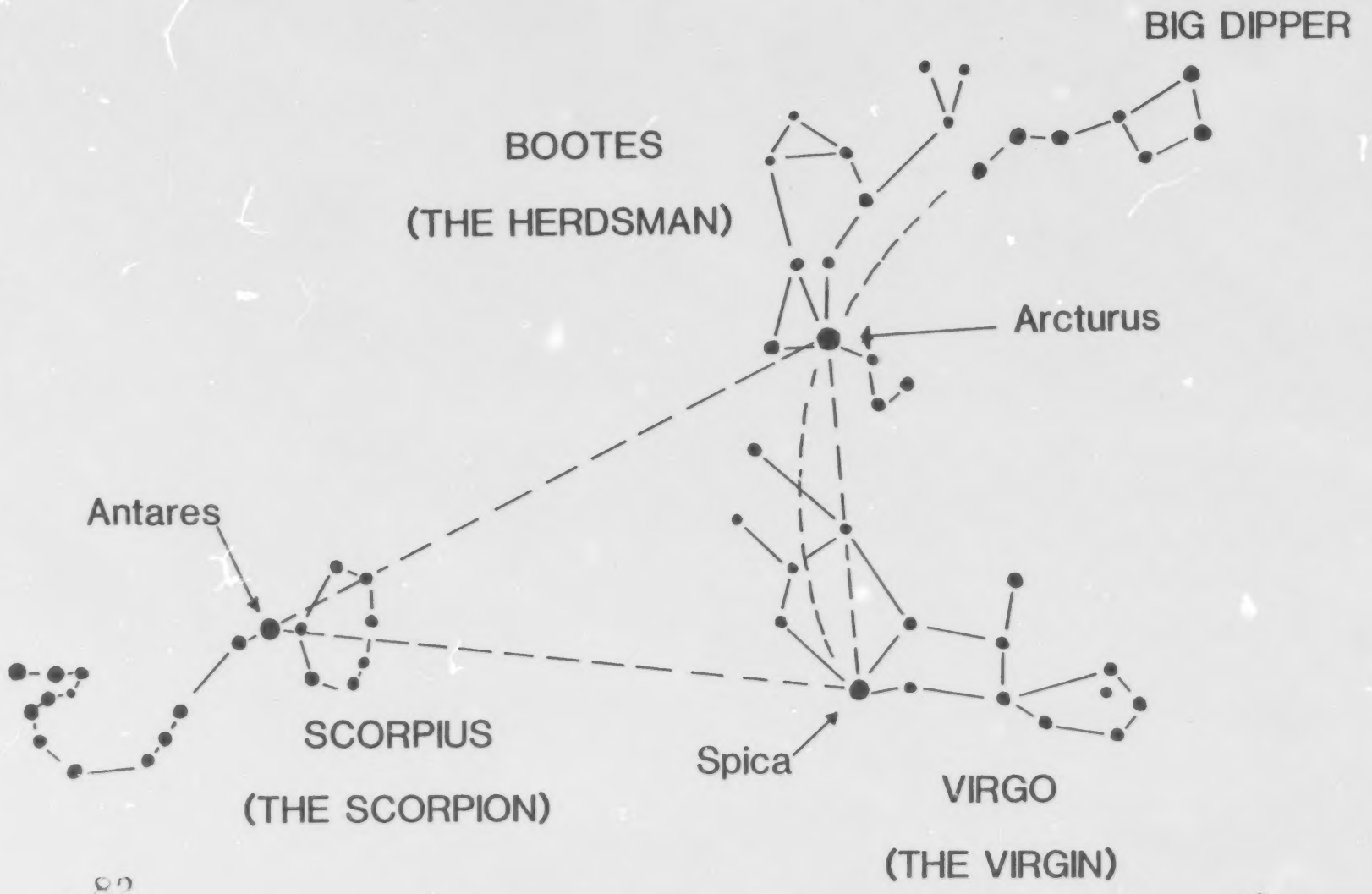


THE BIG TRIANGLE

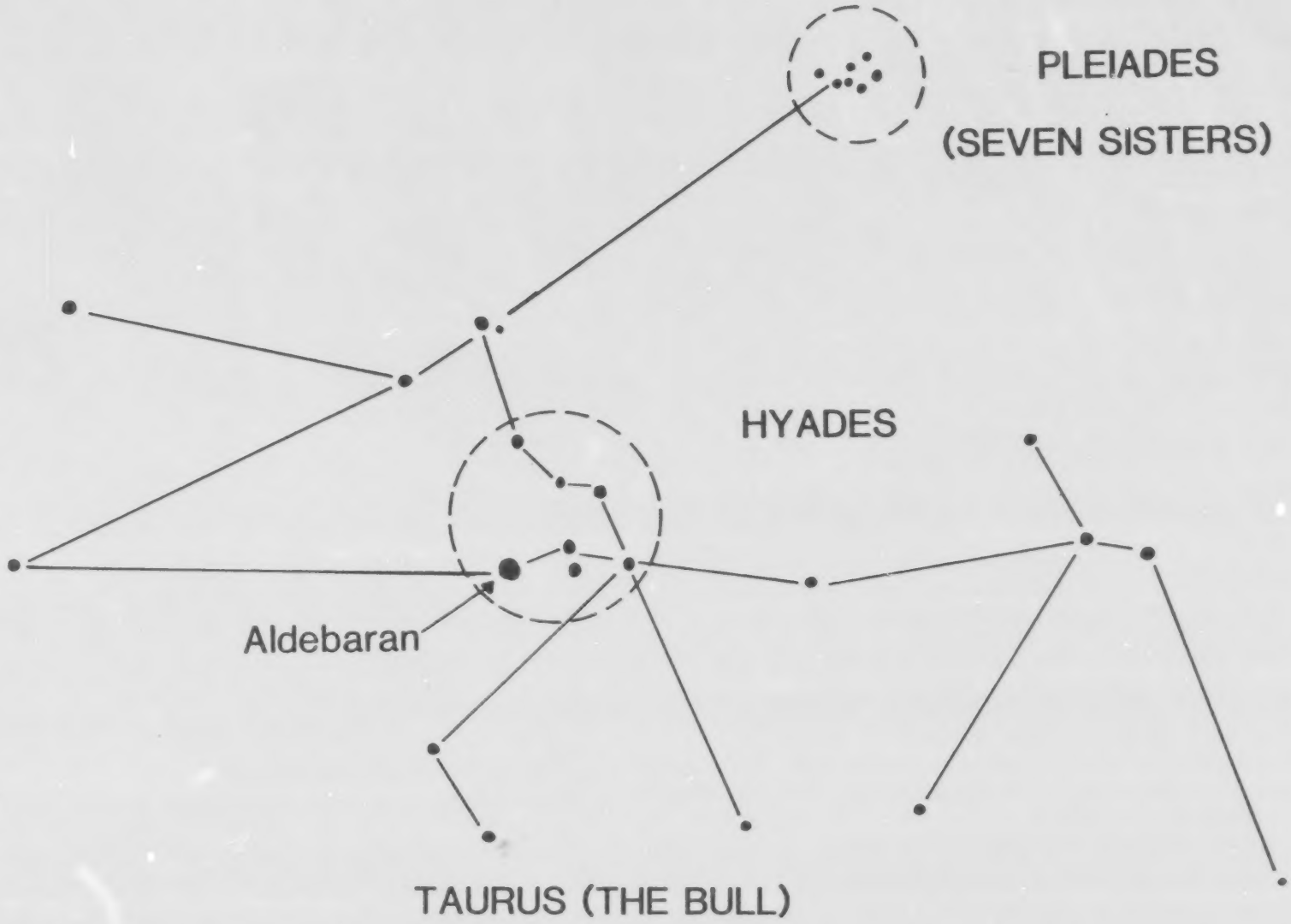


CANIS MAJOR, ORION & TAURUS

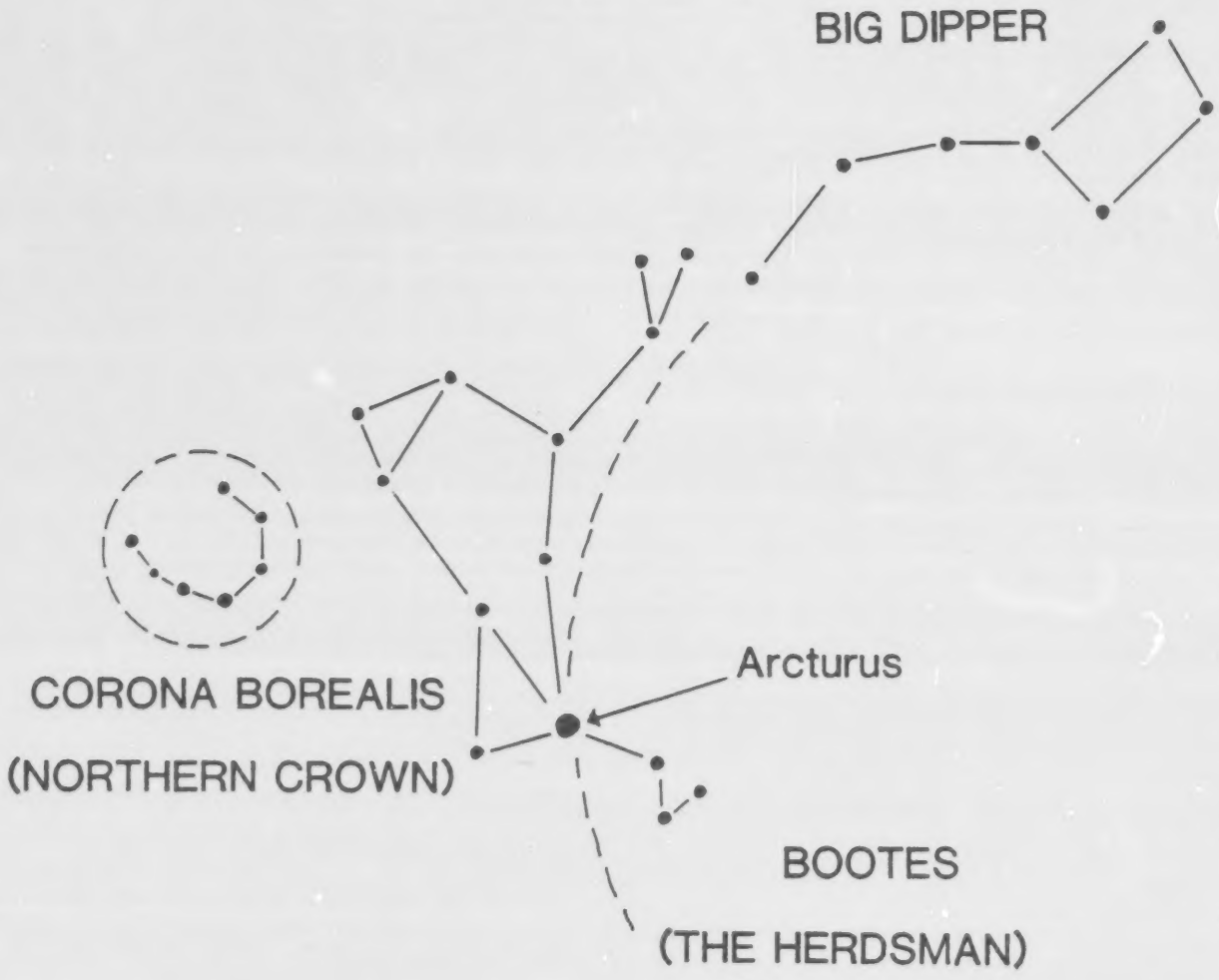
FINDING BOOTES, SCORPIUS & VIRGO



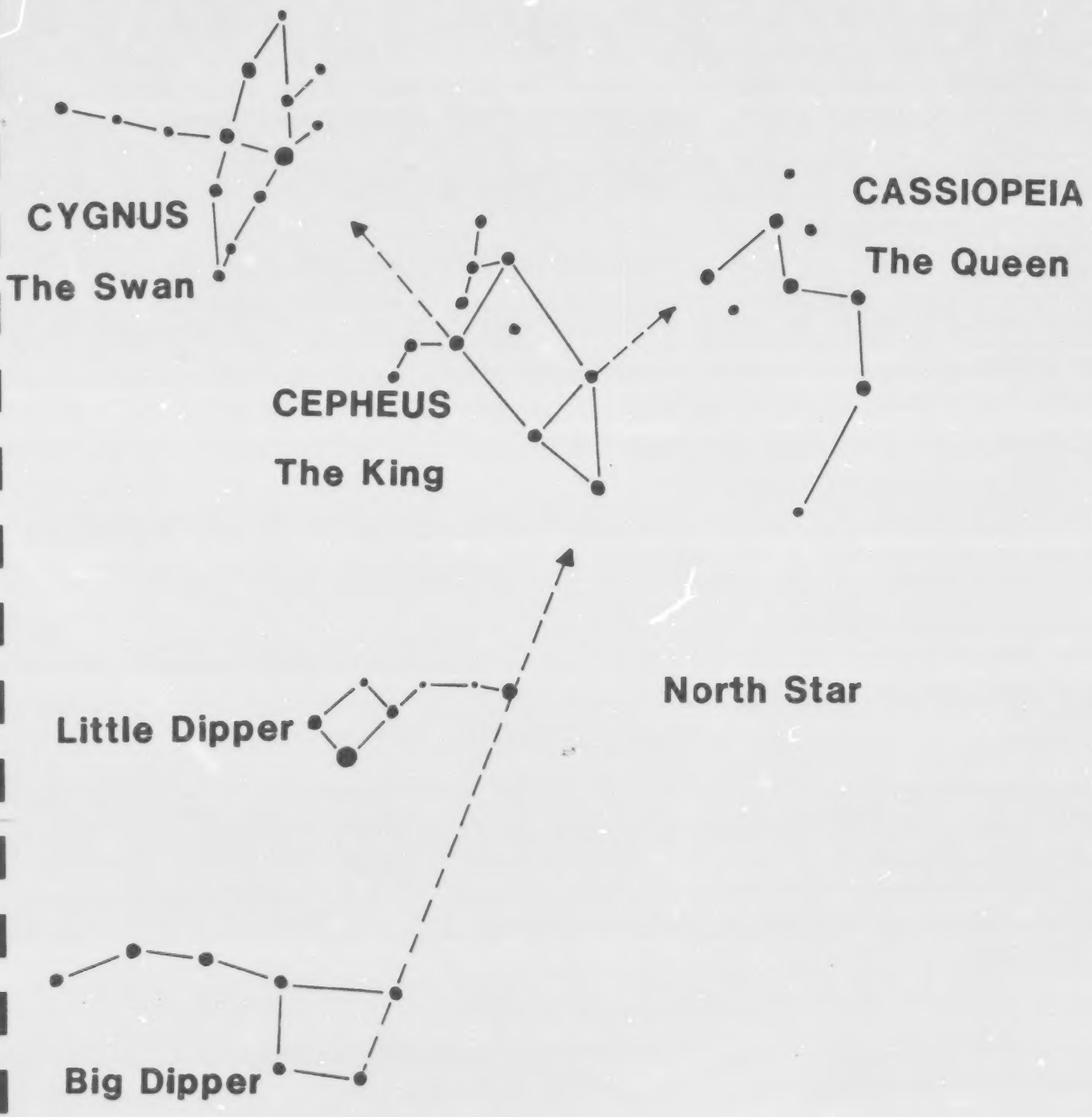
THE PLEIADES & HYADES



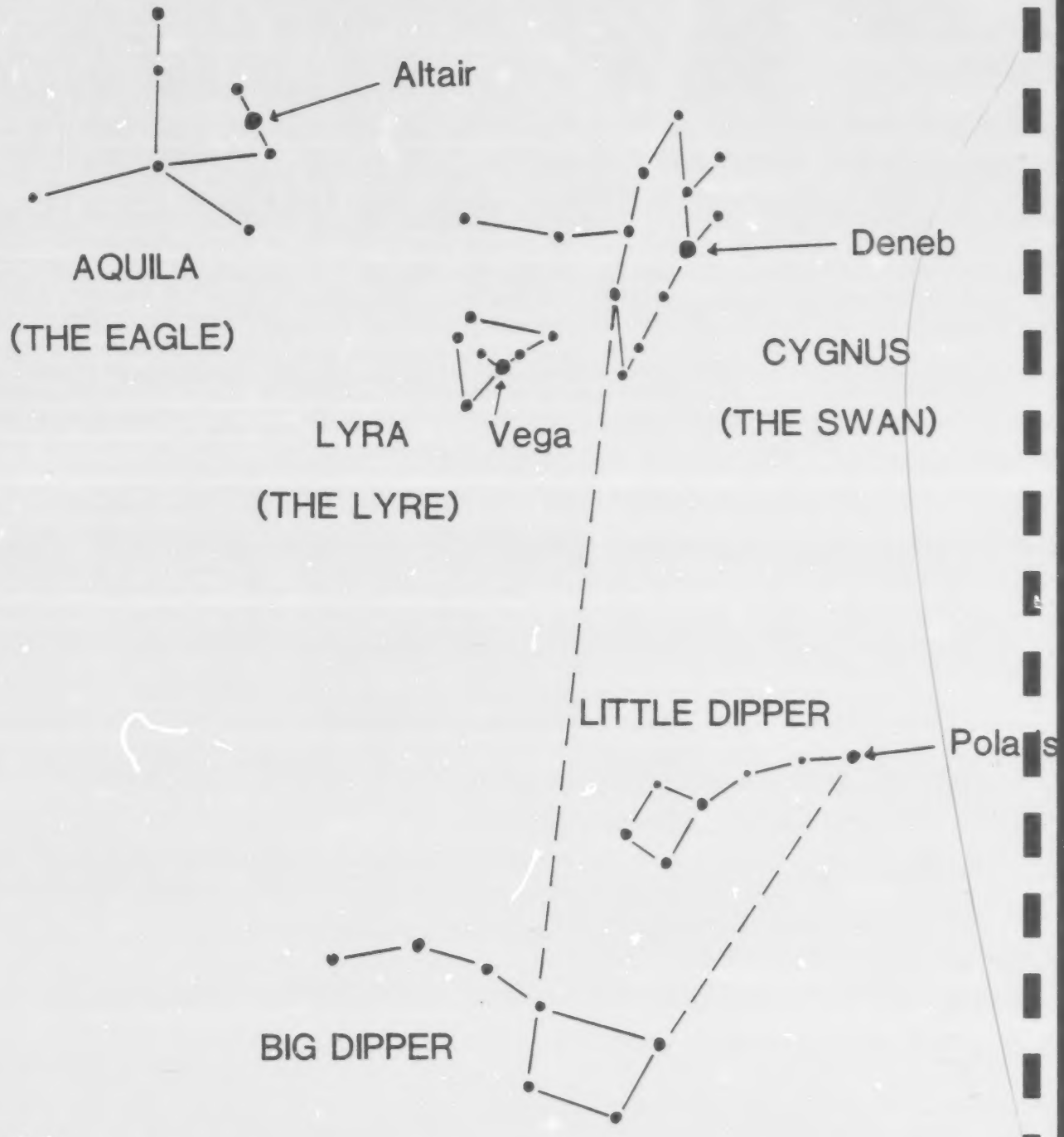
FINDING THE NORTHERN CROWN



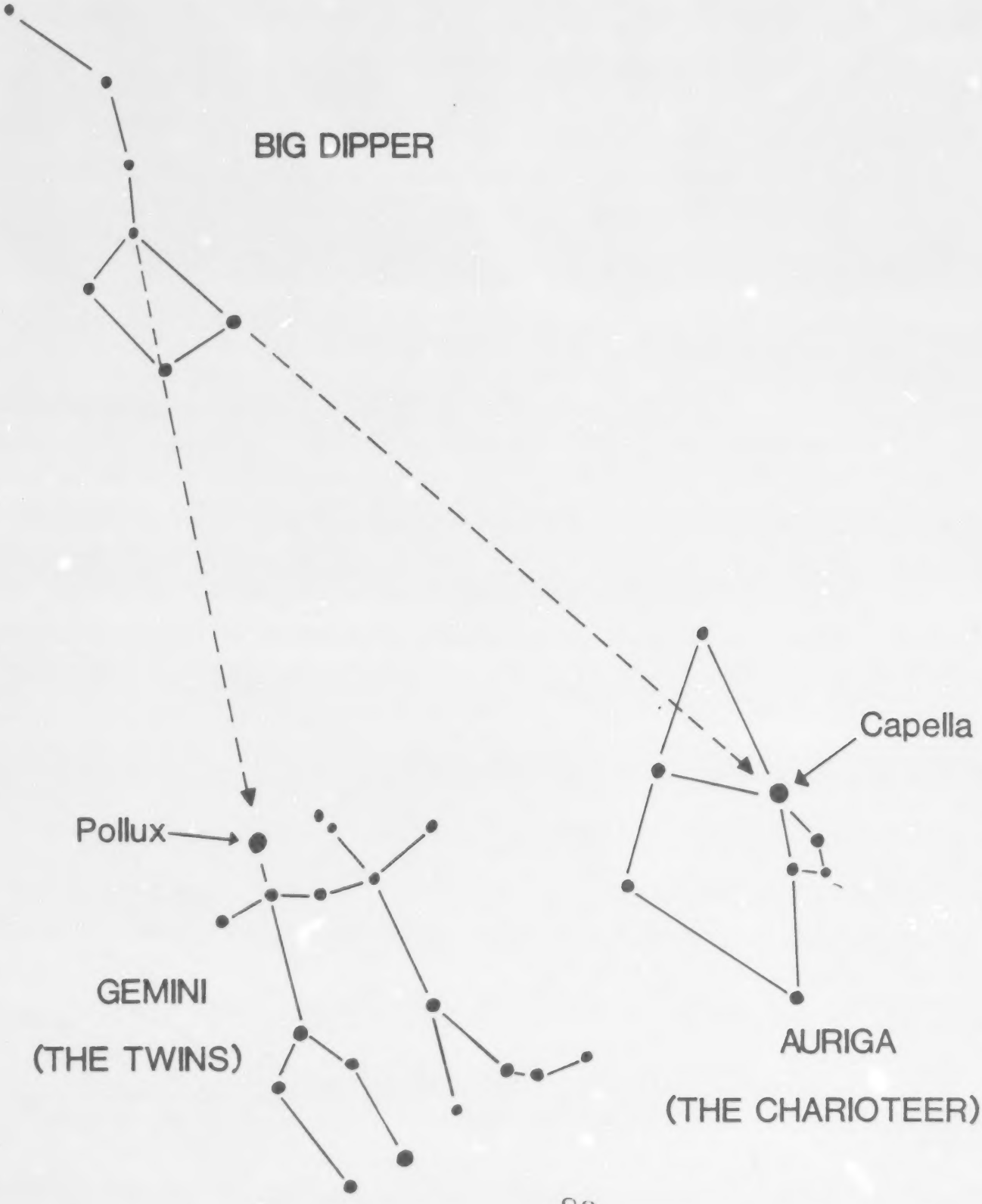
FINDING CEPHEUS, CASSIOPEIA, AND CYGNUS



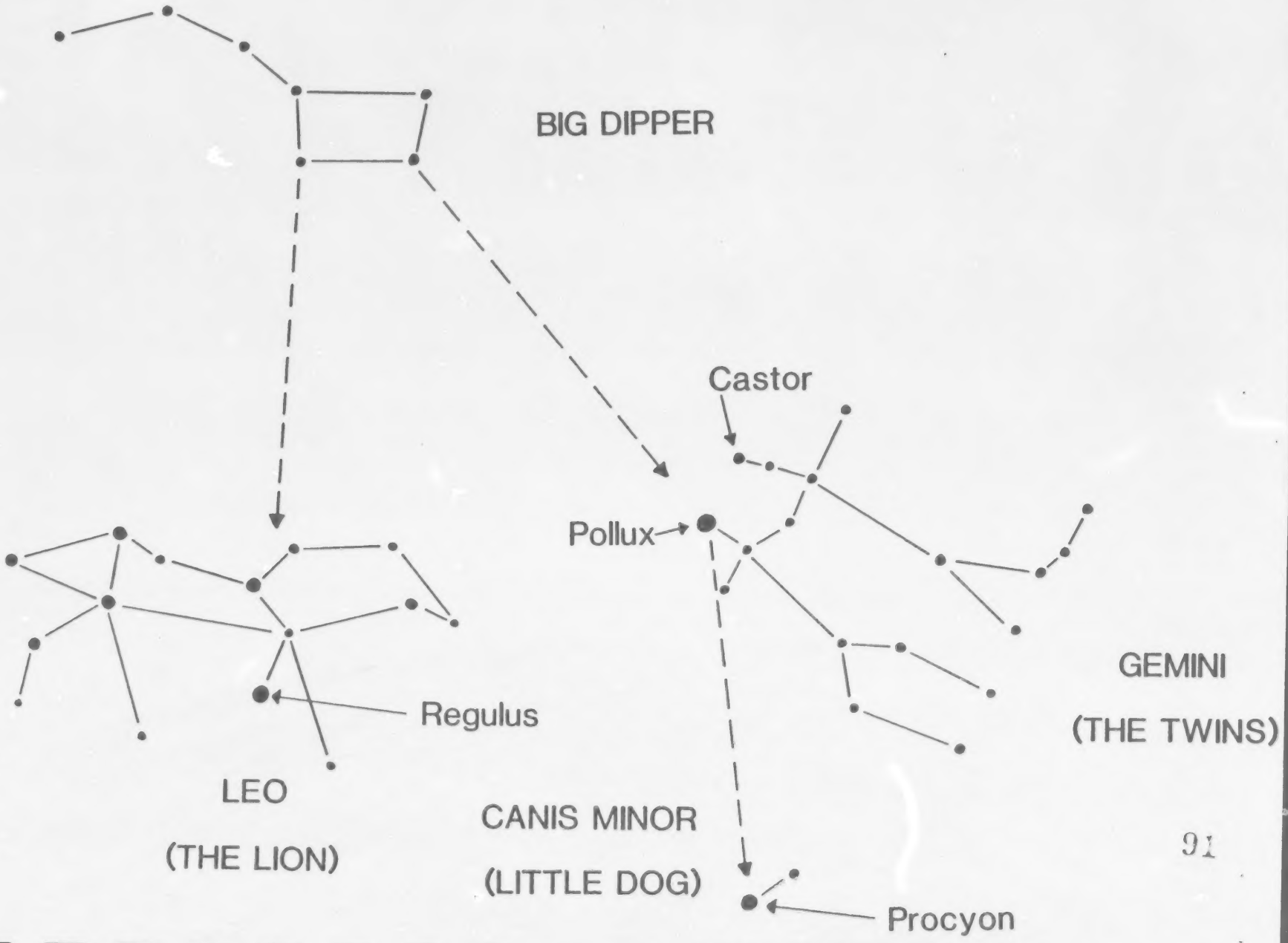
FINDING CYGNUS, LYRA & AQUILA



FINDING GEMINI & AURIGA

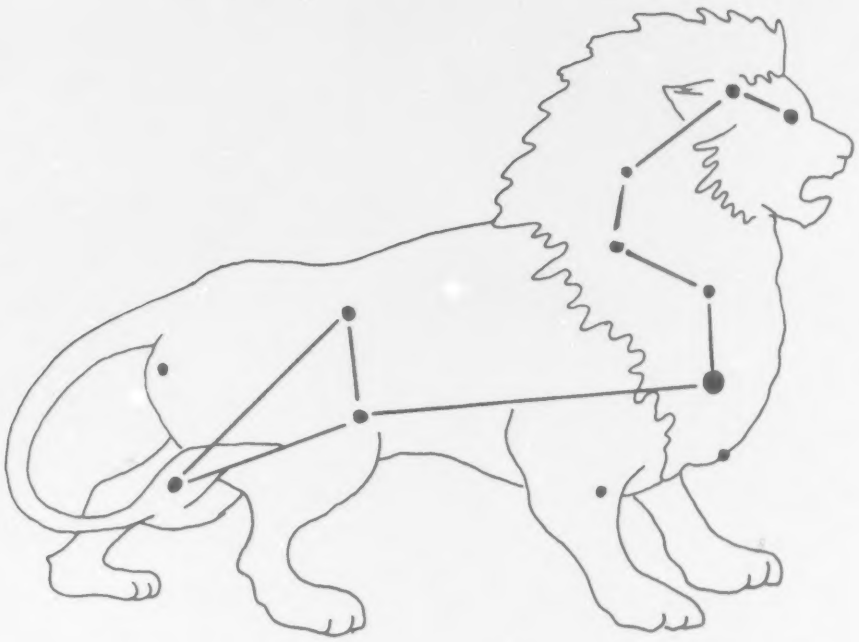


FINDING LEO, CANIS MINOR & GEMINI

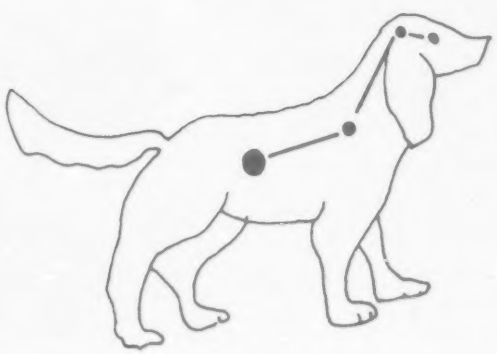


CONSTELLATIONS

Leo, the Lion

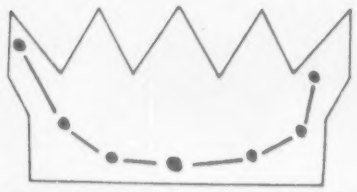


Canis Minor, The Little Dog

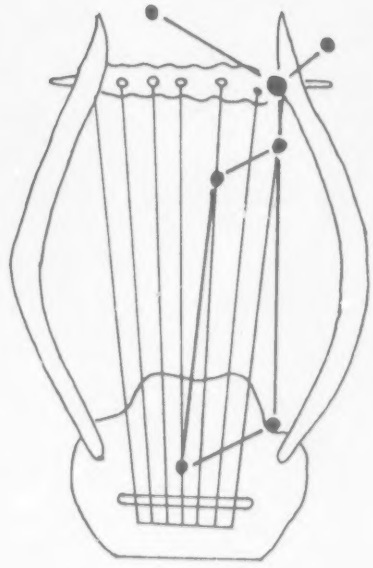


Canis Major , The Big Dog

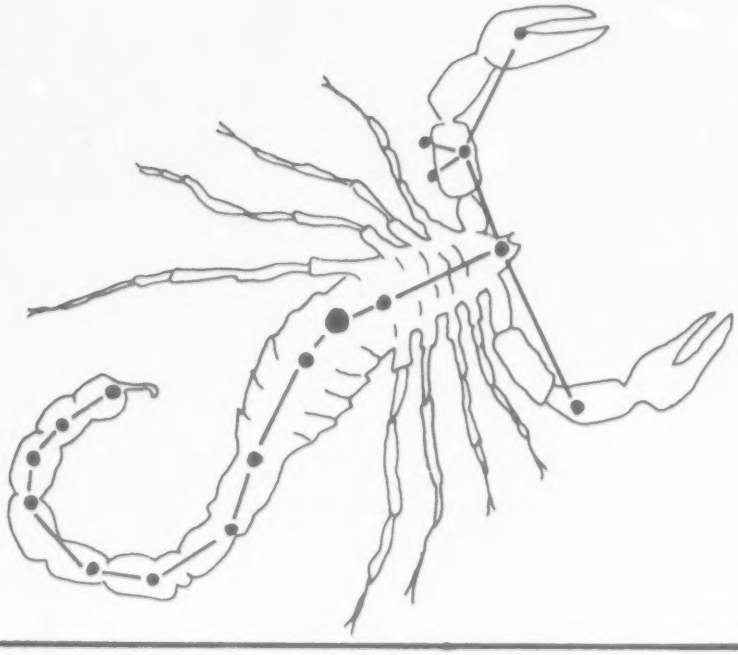
Corona , the Northern Crown



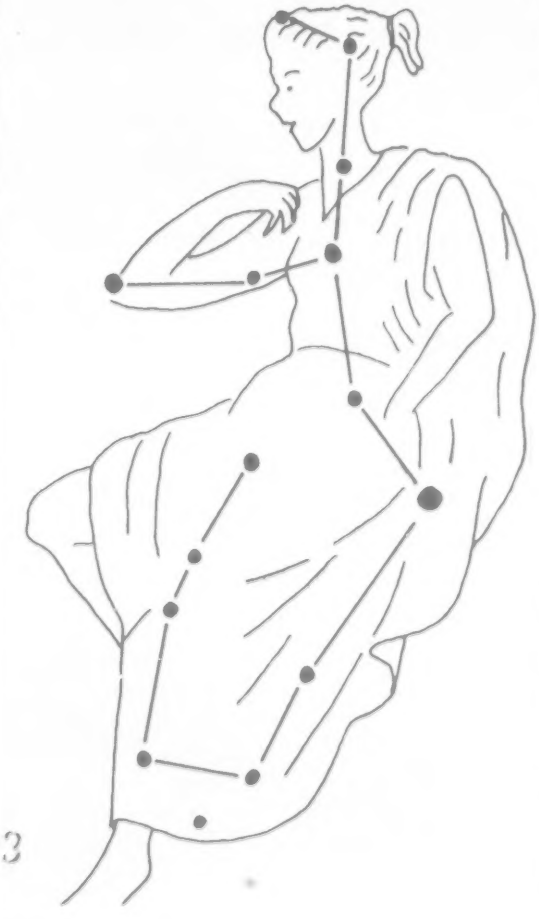
Lyra, the Lyre



Scorpius, the Scorpion

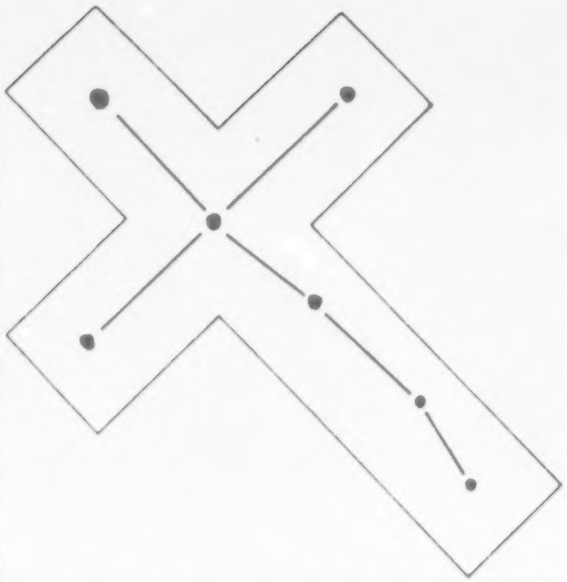


Virgo, the Maiden

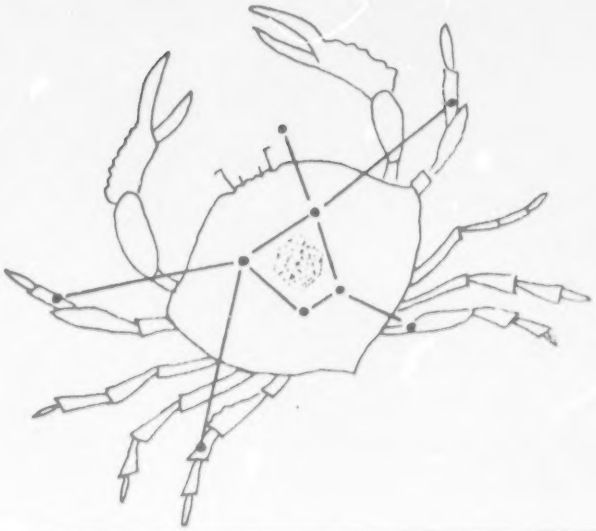


Aquila, the Eagle

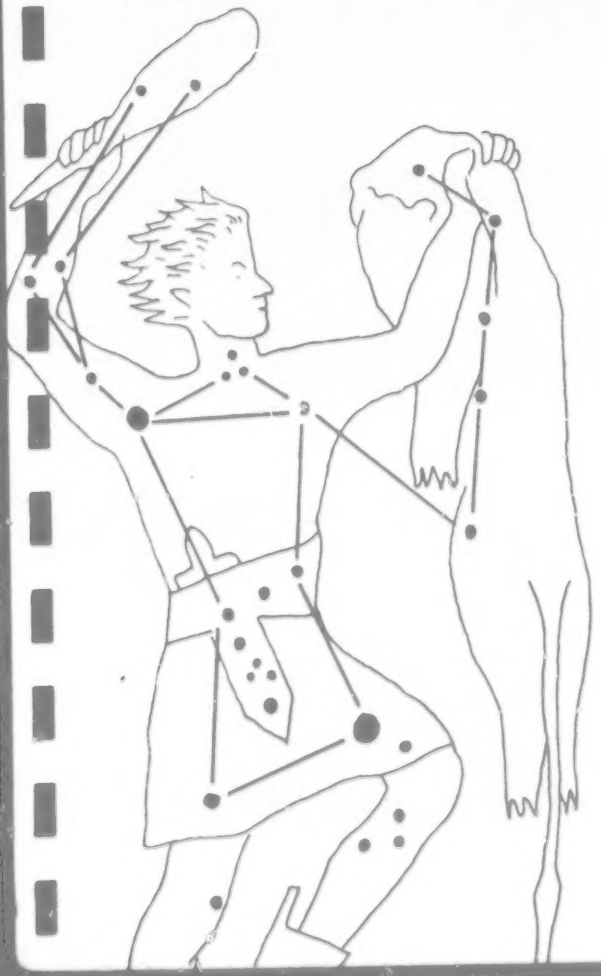
Tne Northern Cross



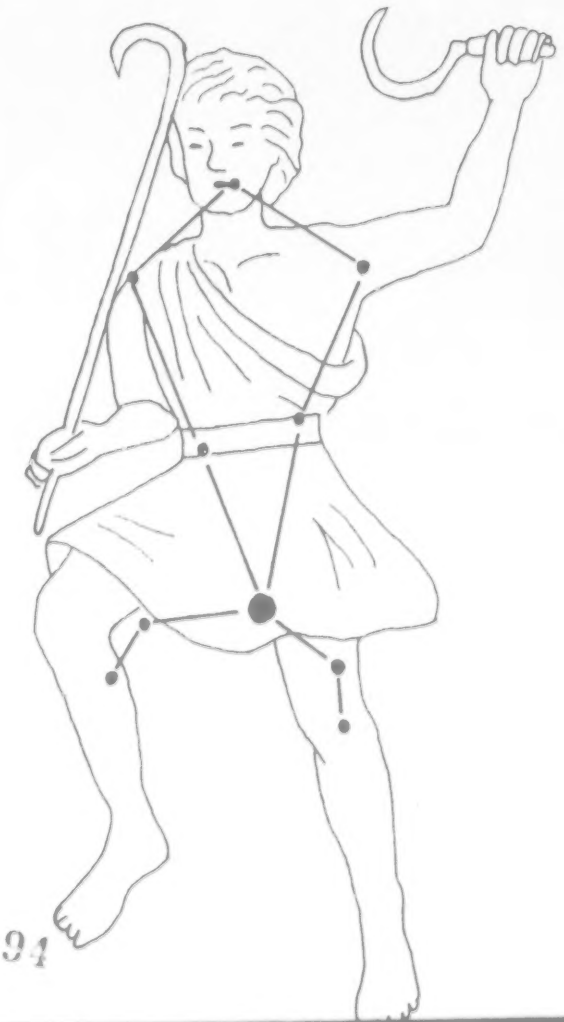
Cancer, the Crab



Orion, the Hunter

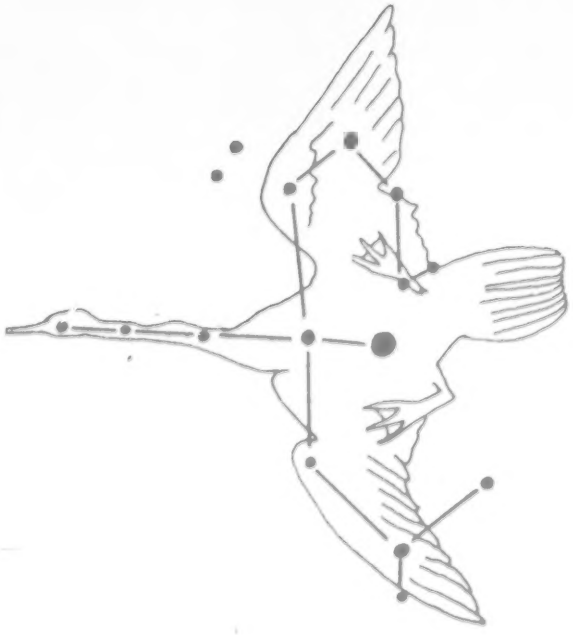


Bootes, the Herdsman

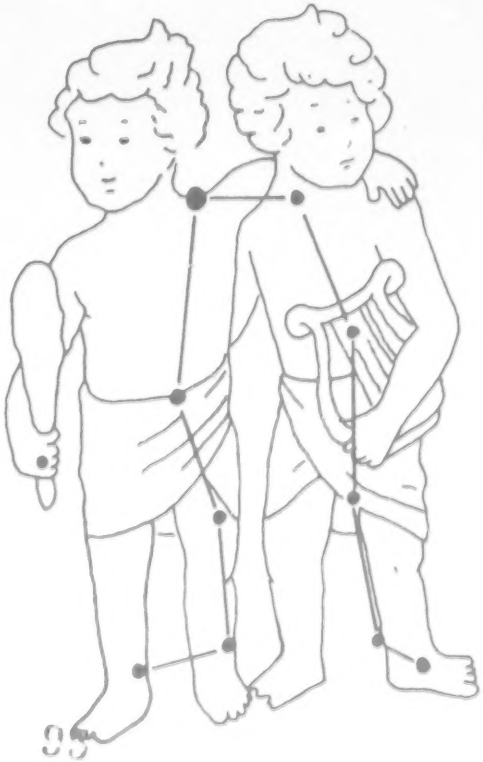


Hercules

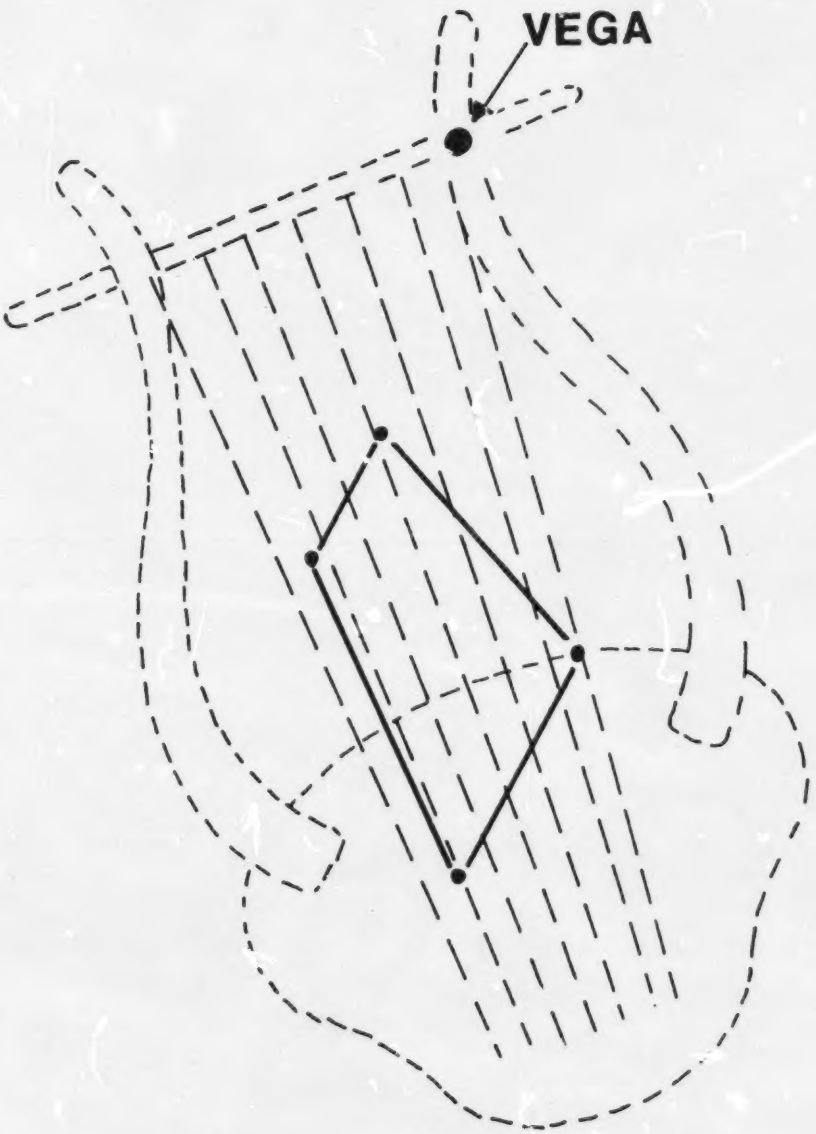
Cygnus, the Swan



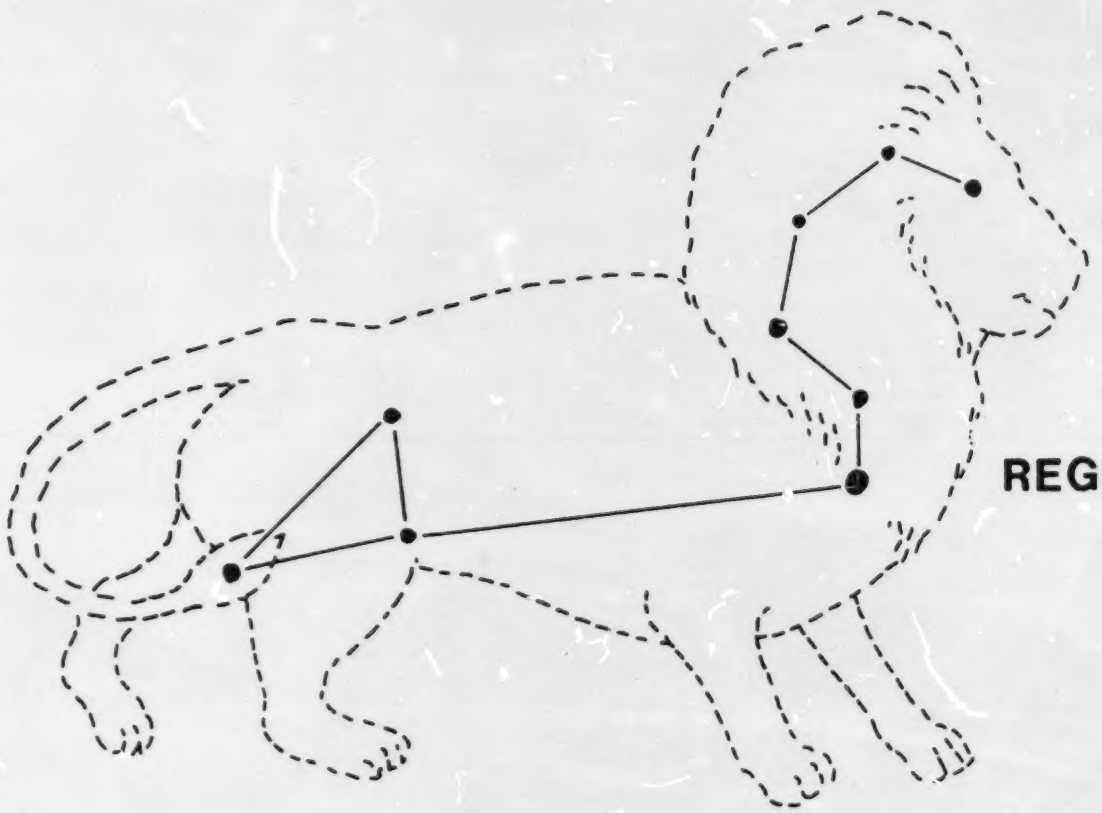
Gemini, the Twins



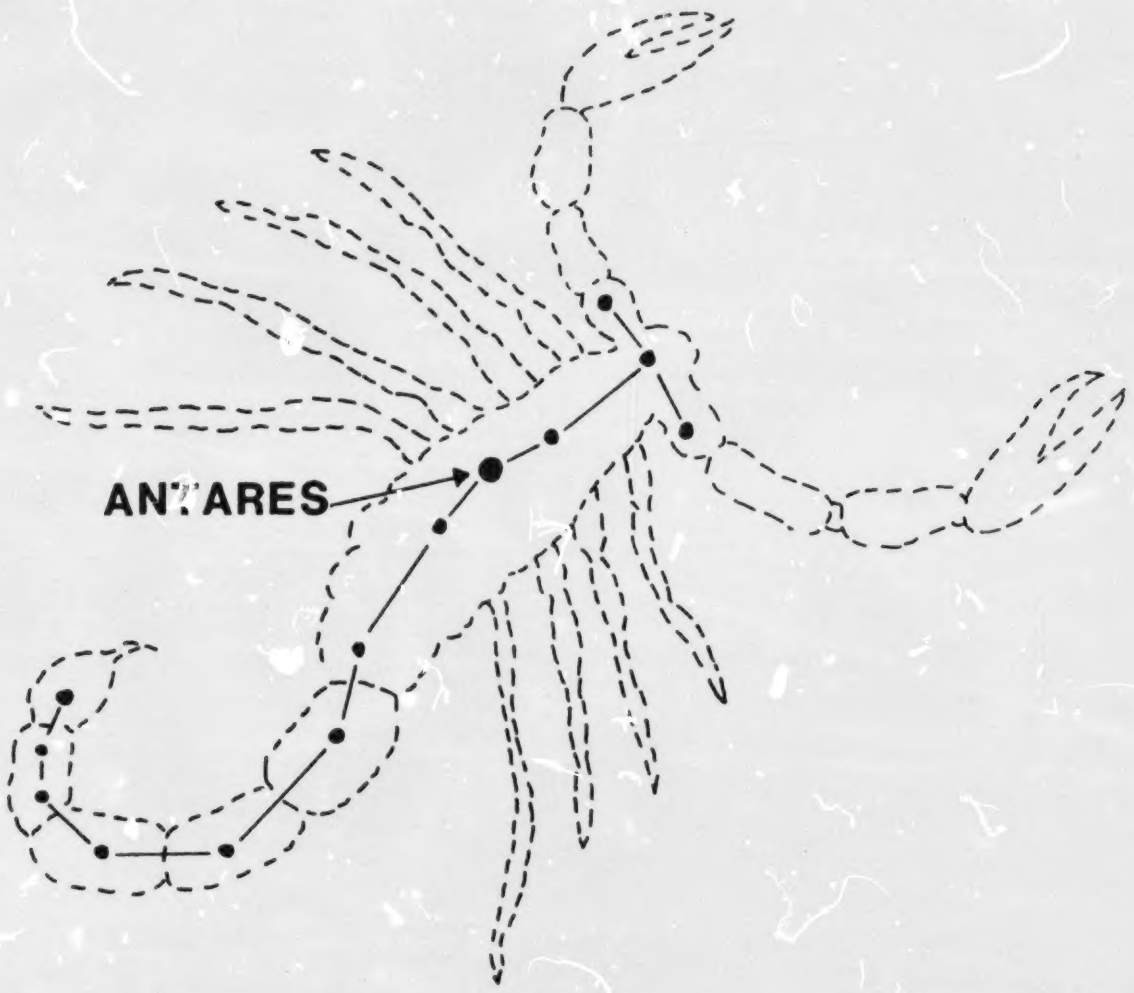
LYRA, THE LYRE



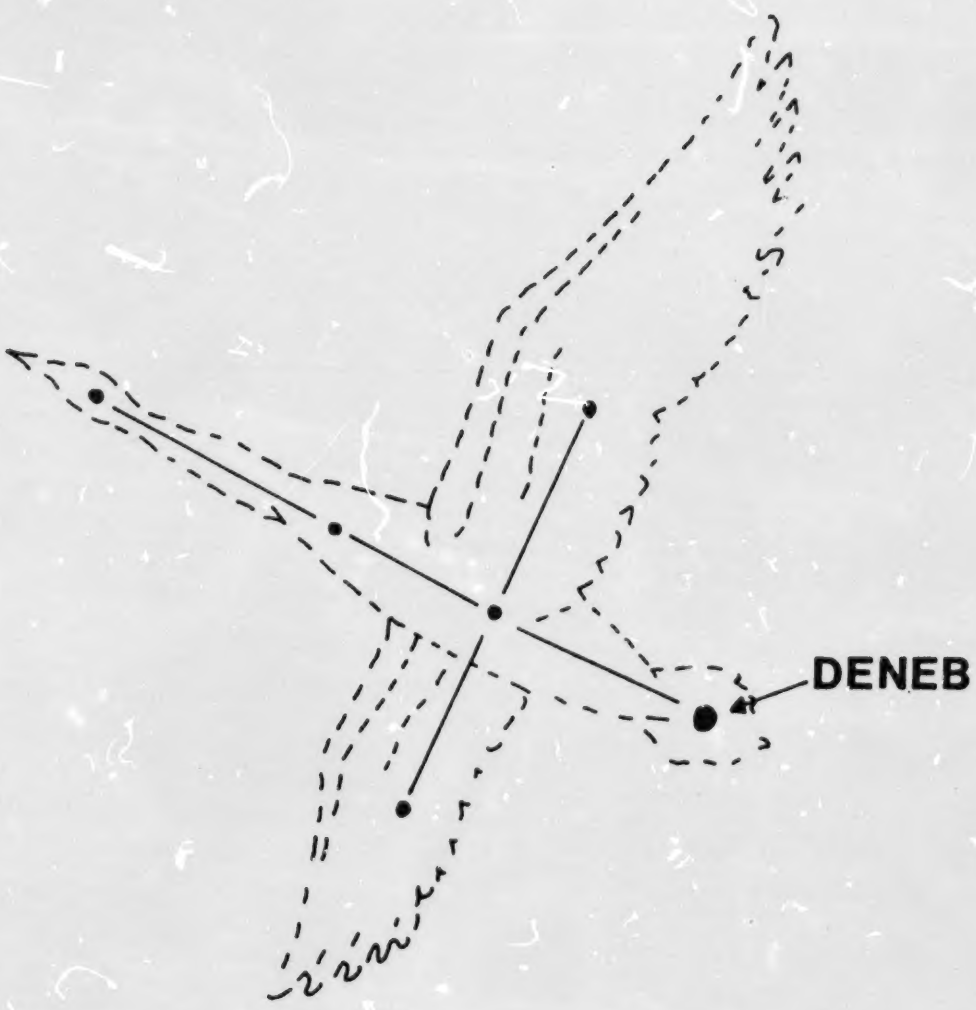
LEO, THE LION



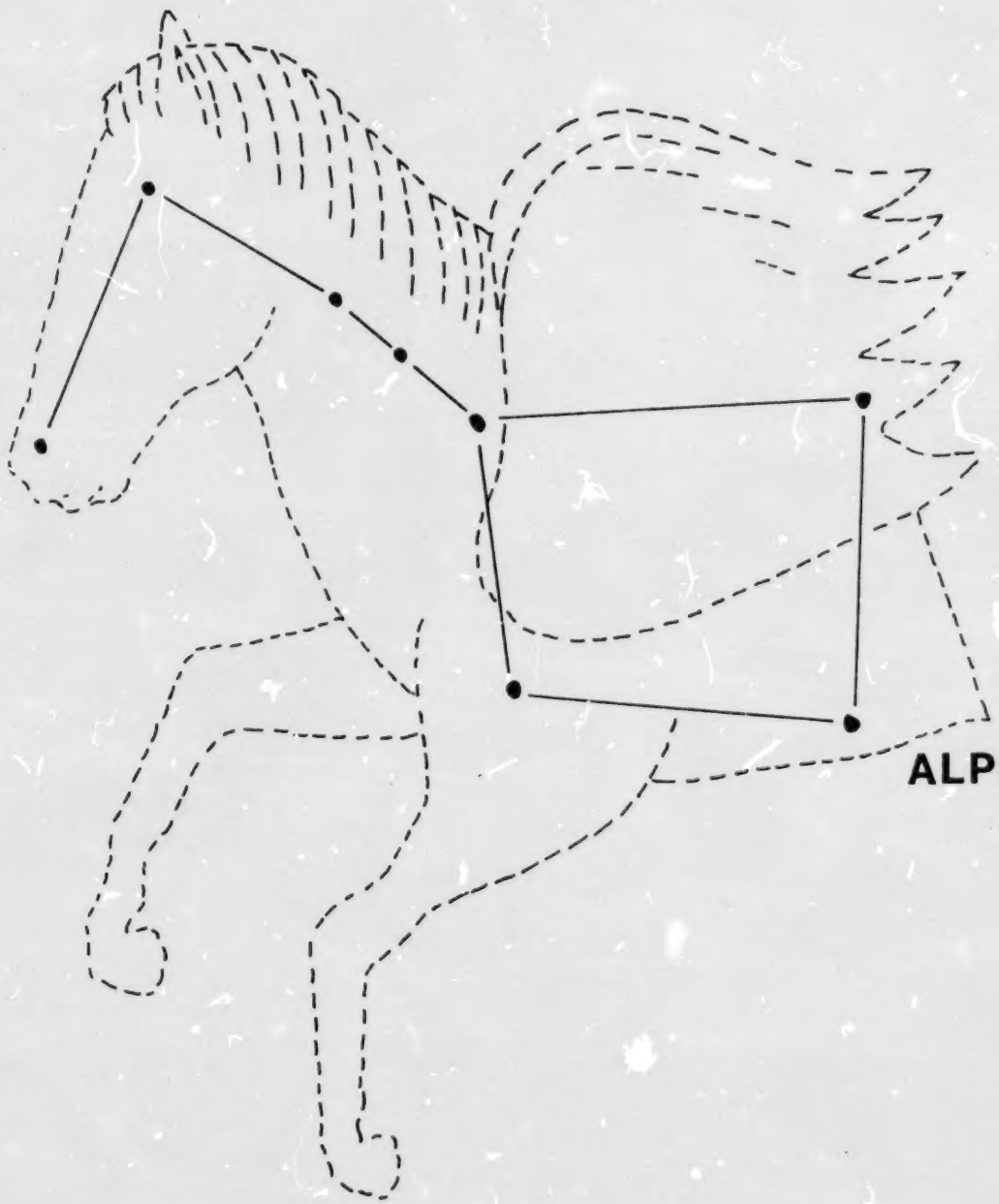
SCORPIUS, THE SCORPION



CYGNUS, THE SWAN



PEGASUS, THE WINGED HORSE



AQUILA, THE EAGLE